MECA482 CSU Chico - Furuta Pendulum Model - Aaron Taylor Angel Sanchez Ingrid Tisell Michele Fragasso Joe Karam

This is the model from Wikipedia. The correspodning publication is "Cazzolato, B.S and Prime, Z (2011) "On the Dynamics of the Furuta Pendulum", Journal of Control Science and Engineering, Volume 2011 (2011), Article ID 528341, 8 pages." However the first model has been used to implement the feedback controller.
This model has been developed initiallit to be run in Simulink. However the model has been later simulated in CoppeliaSim.

```
> with(plots):
  with(CodeGeneration):
  with(VectorCalculus):
  with(LinearAlgebra):
```

```
> merge := proc(x,y)
    [op(x), op(y)]
  end proc;
```

$$merge := \mathbf{proc}(x, y)\ [op(x), op(y)]\ \mathbf{end\ proc} \tag{1.1}$$

```
> linearize := proc(eqs, lin_point)
  local var, vardot, f, var_sub_eqs,var_sub,lin_point_sub,f_sub,
  J,deltax,f_subx0,f_lin_sub,var_sub_eqs_inv,f_lin,
  eqs_space_state;

      var := [seq(lhs(lin_point[i]),i=1..numelems(lin_point))];
      vardot := diff(var,t);
      f:= map(rhs,map(op,solve(eqs,vardot)));
      var_sub_eqs := [seq(var[i]=cat(x,__,i), i = 1..numelems
  (var))];
      var_sub := [seq(rhs(var_sub_eqs[i]), i=1..numelems
  (var_sub_eqs))];
      lin_point_sub := subs(var_sub_eqs, lin_point);
      f_sub := subs(var_sub_eqs, f);
      J := Matrix(evalf(subs(lin_point_sub,Jacobian(f_sub,
  var_sub))));
      deltax:= Transpose(Matrix([seq(var_sub[i] - rhs
  (lin_point_sub[i]), i=1..numelems(var_sub))]));
      f_subx0 := Transpose(Matrix(evalf(subs(lin_point_sub,
  (f_sub)))));
      f_lin_sub := simplify(f_subx0 + J.deltax);
      var_sub_eqs_inv := [seq(rhs(var_sub_eqs[i]) = lhs
  (var_sub_eqs[i]), i =1..numelems(var_sub))];
      f_lin := subs(var_sub_eqs_inv,f_lin_sub);
      eqs_space_state := [seq(vardot[i] = f_lin[i,1],i=1..
  numelems(var))];

  end proc;
```

$$linearize := \mathbf{proc}(eqs, lin\_point) \tag{1.2}$$

$$\mathbf{local}\ var, vardot, f, var\_sub\_eqs, var\_sub, lin\_point\_sub, f\_sub, J, deltax, f\_subx0, f\_lin\_sub, var\_sub\_eqs\_inv, f\_lin, eqs\_space\_state;$$

$$var := [seq(lhs(lin\_point[i]), i = 1..numelems(lin\_point))];$$

$$vardot := VectorCalculus:-diff(var, t);$$

```
f := map(rhs, map(op, solve(eqs, vardot)));
var_sub_eqs := [seq(var[i] = cat(x, __, i), i = 1 ..numelems(var))];
var_sub := [seq(rhs(var_sub_eqs[i]), i = 1 ..numelems(var_sub_eqs))];
lin_point_sub := subs(var_sub_eqs, lin_point);
f_sub := subs(var_sub_eqs, f);
J := Matrix(evalf(subs(lin_point_sub, VectorCalculus:-Jacobian(f_sub, var_sub))));
deltax := LinearAlgebra:-Transpose(Matrix([seq(VectorCalculus:-`+`(var_sub[i],
VectorCalculus:-`-`(rhs(lin_point_sub[i]))), i = 1 ..numelems(var_sub))]));
f_subx0 := LinearAlgebra:-Transpose(Matrix(evalf(subs(lin_point_sub, f_sub))));
f_lin_sub := simplify(VectorCalculus:-`+`(f_subx0, VectorCalculus:-`.`(J, deltax)));
var_sub_eqs_inv := [seq(rhs(var_sub_eqs[i]) = lhs(var_sub_eqs[i]), i = 1
..numelems(var_sub))];
f_lin := subs(var_sub_eqs_inv, f_lin_sub);
eqs_space_state := [seq(vardot[i] = f_lin[i, 1], i = 1 ..numelems(var))]
end proc
```

Equations of Motion with and without parameters

```
> eq1 := diff(theta1(t), t, t)*(J__1zz+m__1*(l__1)^2+(m__2)*
  (L__1)^2+(J__2yy+m__2*(l__2)^2)*sin(theta2(t))^2+J__2xx*cos
  (theta2(t))^2)+diff(theta2(t), t, t)*m__2*L__1*l__2*cos
  (theta2(t))-m__2*L__1*l__2*sin(theta2(t))*diff(theta2(t),t)
  ^2+diff(theta1(t), t)*diff(theta2(t), t)*sin(2*theta2(t))*
  (m__2*l__2^2+J__2yy-J__2xx) + b__1*diff(theta1(t),t) =
  eta__g*k__g*eta__m*k__t*((V__m - k__g*k__m*diff(theta1(t), t)
  )/r__m)
```

$$eq1 := \left(\frac{d^2}{dt^2}\,\theta 1(t)\right)\left(m_2 L_1^2 + m_1 l_1^2 + J_{1zz} + \left(m_2 l_2^2 + J_{2yy}\right)\sin(\theta 2(t))^2 + J_{2xx}\cos(\theta 2(t))^2\right) + \left(\frac{d^2}{dt^2}\,\theta 2(t)\right) m_2 L_1 l_2 \cos(\theta 2(t)) - m_2 L_1 l_2 \sin(\theta 2(t))\left(\frac{d}{dt}\,\theta 2(t)\right)^2 + \left(\frac{d}{dt}\,\theta 1(t)\right)\left(\frac{d}{dt}\,\theta 2(t)\right)\sin(2\,\theta 2(t))\left(m_2 l_2^2 - J_{2xx} + J_{2yy}\right) + b_1\left(\frac{d}{dt}\,\theta 1(t)\right) = \frac{\eta_g k_g \eta_m k_t\left(V_m - k_g k_m\left(\frac{d}{dt}\,\theta 1(t)\right)\right)}{r_m} \tag{1.1.1}$$

```
> eq2 := diff(theta1(t), t, t)*m__2*L__1*l__2*cos(theta2(t))+
  diff(theta2(t), t, t)*(m__2*l__2^2+J__2zz)+1/2*diff(theta1
  (t), t)^2*sin(2*theta2(t))*(-m__2*l__2^2-J__2yy+J__2xx)+b__2*
  diff(theta2(t), t)+g*m__2*l__2*sin(theta2(t)) = tau__2
```

$$eq2 := \left(\frac{d^2}{dt^2}\,\theta 1(t)\right) m_2 L_1 l_2 \cos(\theta 2(t)) + \left(\frac{d^2}{dt^2}\,\theta 2(t)\right)\left(m_2 l_2^2 + J_{2zz}\right) \tag{1.1.2}$$

$$+\frac{\left(\frac{d}{dt}\,\theta 1(t)\right)^2 \sin(2\,\theta 2(t))\,\left(-m_2 l_2^2 + J_{2xx} - J_{2yy}\right)}{2} + b_2\left(\frac{d}{dt}\,\theta 2(t)\right)$$

$$+ g\,m_2\,l_2 \sin(\theta 2(t)) = \tau_2$$

```
> data_mechanical := [J__1zz = 0.0023, m__1 = 0, l__1 = 0.215,
  m__2 = 0.2, L__1 = 0.215, J__2yy = 0.0023, l__2 = 0.1675,
  J__2xx = 0, J__2zz = 0.0023, b__1 = 0, Vm = 0, g=9.81, tau__2
  = 0, b__2 = 0]
```

$$data\_mechanical := \left[J_{1zz} = 0.0023,\ m_1 = 0,\ l_1 = 0.215,\ m_2 = 0.2,\ L_1 = 0.215,\ J_{2yy} = 0.0023,\ l_2 = 0.1675,\ J_{2xx} = 0,\ J_{2zz} = 0.0023,\ b_1 = 0,\ Vm = 0,\ g = 9.81,\ \tau_2 = 0,\ b_2 = 0\right] \quad \textbf{(1.1.3)}$$

```
> data_electrical := [eta__g = 0.85, eta__m = 0.87, k__g = 70,
  k__m = 0.0076 , k__t=0.0076, r__m=2.6, V__m = 10];
```

$$data\_electrical := \left[\eta_g = 0.85,\ \eta_m = 0.87,\ k_g = 70,\ k_m = 0.0076,\ k_t = 0.0076,\ r_m = 2.6,\ V_m = 10\right] \quad \textbf{(1.1.4)}$$

```
> data := merge(data_mechanical, data_electrical);
```

$$data := \left[J_{1zz} = 0.0023,\ m_1 = 0,\ l_1 = 0.215,\ m_2 = 0.2,\ L_1 = 0.215,\ J_{2yy} = 0.0023,\ l_2 = 0.1675,\ J_{2xx} = 0,\ J_{2zz} = 0.0023,\ b_1 = 0,\ Vm = 0,\ g = 9.81,\ \tau_2 = 0,\ b_2 = 0,\ \eta_g = 0.85,\ \eta_m = 0.87,\ k_g = 70,\ k_m = 0.0076,\ k_t = 0.0076,\ r_m = 2.6,\ V_m = 10\right] \quad \textbf{(1.1.5)}$$

```
> eqs := [eq1 ,eq2];
```

$$eqs := \left[\left(\frac{d^2}{dt^2}\,\theta 1(t)\right)\left(m_2 L_1^2 + m_1 l_1^2 + J_{1zz} + \left(m_2 l_2^2 + J_{2yy}\right)\sin(\theta 2(t))^2\right.\right. \quad \textbf{(1.1.6)}$$

$$\left. + J_{2xx}\cos(\theta 2(t))^2\right) + \left(\frac{d^2}{dt^2}\,\theta 2(t)\right) m_2 L_1 l_2 \cos(\theta 2(t))$$

$$- m_2 L_1 l_2 \sin(\theta 2(t))\left(\frac{d}{dt}\,\theta 2(t)\right)^2 + \left(\frac{d}{dt}\,\theta 1(t)\right)\left(\frac{d}{dt}\right.$$

$$\left.\theta 2(t)\right) \sin(2\,\theta 2(t))\left(m_2 l_2^2 - J_{2xx} + J_{2yy}\right) + b_1\left(\frac{d}{dt}\,\theta 1(t)\right)$$

$$= \frac{\eta_g k_g \eta_m k_t\left(V_m - k_g k_m\left(\frac{d}{dt}\,\theta 1(t)\right)\right)}{r_m},\ \left(\frac{d^2}{dt^2}\,\theta 1(t)\right) m_2 L_1 l_2 \cos(\theta 2(t))$$

$$+ \left(\frac{d^2}{dt^2}\,\theta 2(t)\right)\left(m_2 l_2^2 + J_{2zz}\right)$$

$$+\frac{\left(\frac{d}{dt}\,\theta 1(t)\right)^2 \sin(2\,\theta 2(t))\,\left(-m_2 l_2^2 + J_{2xx} - J_{2yy}\right)}{2} + b_2\left(\frac{d}{dt}\,\theta 2(t)\right)$$

$$+ g\,m_2\,l_2 \sin(\theta 2(t)) = \tau_2\Bigg]$$

Simulation

Reducing to first order system of ODEs and Exporting model to Matlab(to simulate it in Simulink)

Reducing to state space model and exporting to Matlab

```
> eqs_first_order;
```

$$\Bigg[\left(\frac{d}{dt}\,theta1dot(t)\right)\left(m_2 L_1^2 + m_1 l_1^2 + J_{1zz} + \left(m_2 l_2^2 + J_{2yy}\right)\sin(\theta 2(t))^2\right. \tag{1.4.1}$$

$$\left. + J_{2xx}\cos(\theta 2(t))^2\right) + \left(\frac{d}{dt}\,theta2dot(t)\right) m_2 L_1 l_2 \cos(\theta 2(t))$$

$$- m_2 L_1 l_2 \sin(\theta 2(t))\,theta2dot(t)^2$$

$$+ theta1dot(t)\,theta2dot(t)\sin(2\,\theta 2(t))\left(m_2 l_2^2 - J_{2xx} + J_{2yy}\right) + b_1\,theta1dot(t)$$

$$= \frac{\eta_g k_g \eta_m k_t \left(V_m - k_g k_m\,theta1dot(t)\right)}{r_m}, \left(\frac{d}{dt}\,theta1dot(t)\right) m_2 L_1 l_2 \cos(\theta 2(t))$$

$$+ \left(\frac{d}{dt}\,theta2dot(t)\right)\left(m_2 l_2^2 + J_{2zz}\right)$$

$$+ \frac{theta1dot(t)^2 \sin(2\,\theta 2(t))\left(-m_2 l_2^2 + J_{2xx} - J_{2yy}\right)}{2} + b_2\,theta2dot(t)$$

$$+ g\,m_2\,l_2 \sin(\theta 2(t)) = \tau_2,\ \frac{d}{dt}\,\theta 1(t) = theta1dot(t),\ \frac{d}{dt}\,\theta 2(t) = theta2dot(t)\Bigg]$$

```
> lin_point := [theta1(t) = 2.99, theta2(t) = Pi, theta1dot(t)
  = 0, theta2dot(t) = 0];
```

$$lin\_point := [\theta 1(t) = 2.99,\ \theta 2(t) = \pi,\ theta1dot(t) = 0,\ theta2dot(t) = 0] \tag{1.4.2}$$

```
> eqs_space_state := linearize(eqs_first_order,lin_point):
> dof := [theta1(t), theta2(t), theta1dot(t), theta2dot(t)];
```

$$dof := [\theta 1(t),\ \theta 2(t),\ theta1dot(t),\ theta2dot(t)] \tag{1.4.3}$$

```
> eqs_space_state2 := op(solve(eqs_space_state, var)):
  A, RES := GenerateMatrix(map(rhs,eqs_space_state2),dof):
```

```
> B, RES := GenerateMatrix([seq(RES[i],i=1..4)],[V__m]):
```

Space State Matrixes

```
> A := Matrix(A):
  A_data := subs(data, A);
```

$$A\_data := \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 59.98558162 & -16.13923708 & -0. \\ 0 & 96.15182815 & -14.69336136 & -0. \end{bmatrix} \quad (1.4.1.1)$$

```
> B := Matrix(B):
  B_data := subs(data, B);
```

$$B\_data := \begin{bmatrix} 0 \\ 0 \\ -30.33691204 \\ -27.61910058 \end{bmatrix} \quad (1.4.1.2)$$

```
> C = Matrix([[1, 0, 0, 0], [0, 1, 0, 0], [0, 0, 1, 0], [0,
  0, 0, 1]]);
```

$$C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (1.4.1.3)$$

```
> Eigenvalues(A_data);
```

$$\begin{bmatrix} 0. \, I \\ -19.3199169910745 + 0. \, I \\ 7.69202312225786 + 0. \, I \\ -4.51134321118345 + 0. \, I \end{bmatrix} \quad (1.4.1.4)$$

Exporting to Matlab

Matrixes

```
> Matlab(A, resultname="A");
  Matlab(A_data, resultname="dtheta1_dt");
A = [0 0 1 0; 0 0 0 1; 0 -0.3531740136e10 *
(0.8204135230e19 * V__m * eta__g * eta__m * k__g * k__t
* l__2 ^ 4 * m__2 ^ 3 * L__1 ^ 2 - 0.8204135230e19 *
V__m * eta__g * eta__m * k__g * k__t * l__2 ^ 4 * m__2
^ 2 * J__2xx + 0.8204135230e19 * V__m * eta__g * eta__m
* k__g * k__t * l__2 ^ 4 * m__2 ^ 2 * J__2yy +
0.1640827046e20 * V__m * eta__g * eta__m * k__g * k__t
* l__2 ^ 4 * m__2 ^ 2 * J__2zz + 0.8204135230e19 *
J__2zz ^ 2 * V__m * eta__g * eta__m * k__g * k__t *
l__2 ^ 2 * m__2 - 0.1000000000e29 * L__1 * l__2 ^ 2 *
m__2 ^ 2 * r__m * g * J__2zz * l__1 ^ 2 * m__1 +
0.4102067616e19 * L__1 * l__2 * m__2 * r__m * tau__2 *
J__2zz * l__1 ^ 2 * m__1 - 0.1640827046e20 * V__m *
```

```
eta__g * eta__m * k__g * k__t * l__2 ^ 2 * m__2 *
J__2xx * J__2zz + 0.1640827046e20 * V__m * eta__g *
eta__m * k__g * k__t * l__2 ^ 2 * m__2 * J__2yy *
J__2zz + 0.8204135230e19 * J__2zz * V__m * eta__g *
eta__m * k__g * k__t * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 -
0.1000000000e29 * L__1 * l__2 ^ 4 * m__2 ^ 3 * r__m * g
* l__1 ^ 2 * m__1 - 0.1000000000e29 * L__1 * l__2 ^ 2 *
m__2 ^ 2 * r__m * g * J__1zz * J__2zz + 0.4102067616e19
* L__1 * l__2 ^ 3 * m__2 ^ 2 * r__m * tau__2 * l__1 ^ 2
* m__1 + 0.4102067616e19 * L__1 * l__2 * m__2 * r__m *
tau__2 * J__1zz * J__2zz - 0.1000000000e29 * L__1 * g *
l__2 ^ 2 * m__2 ^ 2 * r__m * J__2xx * J__2zz +
0.1682695872e10 * L__1 * g * l__2 ^ 2 * m__2 ^ 2 * r__m
* J__2yy * J__2zz - 0.4102067614e19 * L__1 * l__2 *
m__2 * r__m * tau__2 * J__2xx * J__2zz +
0.8204135230e19 * L__1 * l__2 * m__2 * r__m * tau__2 *
J__2yy * J__2zz + 0.8204135230e19 * V__m * eta__g *
eta__m * k__g * k__t * l__2 ^ 6 * m__2 ^ 3 -
0.8204135230e19 * J__2zz ^ 2 * V__m * eta__g * eta__m *
k__g * k__t * J__2xx + 0.8204135230e19 * J__2zz ^ 2 *
V__m * eta__g * eta__m * k__g * k__t * J__2yy -
0.1000000000e29 * L__1 * g * l__2 ^ 4 * m__2 ^ 3 * r__m
* J__2xx + 0.1682695872e10 * L__1 * g * l__2 ^ 4 * m__2
^ 3 * r__m * J__2yy + 0.1682695872e10 * L__1 * g * l__2
^ 4 * m__2 ^ 3 * r__m * J__2zz - 0.4102067614e19 * L__1
* l__2 ^ 3 * m__2 ^ 2 * r__m * tau__2 * J__2xx +
0.8204135230e19 * L__1 * l__2 ^ 3 * m__2 ^ 2 * r__m *
tau__2 * J__2yy + 0.8204135230e19 * L__1 * l__2 ^ 3 *
m__2 ^ 2 * r__m * tau__2 * J__2zz - 0.1000000000e29 *
L__1 * l__2 ^ 4 * m__2 ^ 3 * r__m * g * J__1zz -
0.1000000000e29 * L__1 ^ 3 * l__2 ^ 2 * m__2 ^ 3 * r__m
* g * J__2zz + 0.4102067616e19 * L__1 * l__2 ^ 3 * m__2
^ 2 * r__m * tau__2 * J__1zz + 0.4102067616e19 * L__1 ^
3 * l__2 * m__2 ^ 2 * r__m * tau__2 * J__2zz +
0.3365391745e10 * L__1 ^ 3 * g * l__2 ^ 4 * m__2 ^ 4 *
r__m + 0.1682695872e10 * L__1 * g * l__2 ^ 6 * m__2 ^ 4
* r__m + 0.8204135230e19 * L__1 ^ 3 * l__2 ^ 3 * m__2 ^
3 * r__m * tau__2 + 0.8204135230e19 * L__1 * l__2 ^ 5 *
m__2 ^ 3 * r__m * tau__2) / r__m / (0.3531740136e38 *
l__1 ^ 4 * l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * l__1 ^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3
+ 0.1188568910e20 * J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2
^ 3 + 0.7063480271e38 * J__1zz * J__2xx * l__2 ^ 4 *
m__2 ^ 2 + 0.1188568910e20 * J__1zz * J__2yy * l__2 ^ 4
* m__2 ^ 2 + 0.2377137820e20 * J__1zz * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.1188568910e20 * J__2xx * J__2yy * l__2
^ 4 * m__2 ^ 2 + 0.2377137820e20 * J__2xx * J__2zz *
l__2 ^ 4 * m__2 ^ 2 + 0.4e1 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.1188568910e20 * J__2zz ^ 2 * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.7063480271e38 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.7063480271e38 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.1188568910e20 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.7063480271e38
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.7063480271e38 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.7063480271e38 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
```

```
m__1 + 0.1188568910e20 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.2e1 * J__2yy ^ 2 * J__2zz * l__2 ^ 2 * m__2
+ 0.1188568910e20 * J__2yy * J__2zz ^ 2 * L__1 ^ 2 *
m__2 + 0.1188568910e20 * J__2yy * J__2zz ^ 2 * l__1 ^ 2
* m__1 + 0.2e1 * J__2yy * J__2zz ^ 2 * l__2 ^ 2 * m__2
+ 0.1188568910e20 * J__1zz * l__2 ^ 6 * m__2 ^ 3 +
0.1188568910e20 * J__2xx * l__2 ^ 6 * m__2 ^ 3 + 0.2e1
* J__2yy * l__2 ^ 6 * m__2 ^ 3 + 0.2e1 * J__2zz * l__2
^ 6 * m__2 ^ 3 + 0.3531740136e38 * J__1zz ^ 2 * l__2 ^
4 * m__2 ^ 2 + 0.3531740136e38 * J__2xx ^ 2 * l__2 ^ 4
* m__2 ^ 2 + J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.3531740136e38 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.3531740136e38 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 + 0.7063480271e38 *
J__1zz * J__2xx * J__2zz ^ 2 + 0.1188568910e20 * J__1zz
* J__2yy * J__2zz ^ 2 + 0.1188568910e20 * J__2xx *
J__2yy * J__2zz ^ 2 + 0.7063480271e38 * J__2zz * L__1 ^
2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 +
0.1412696054e39 * J__1zz * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.1412696054e39 * J__2xx * J__2zz *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.2377137820e20 *
J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.7063480271e38 * J__1zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__2xx * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.1188568910e20 * J__2yy * l__1 ^
2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.7063480271e38 *
J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^ 2 * m__2 +
0.2377137820e20 * J__2zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__1zz * J__2zz * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__2xx *
J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.7063480271e38 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.1188568910e20 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.1412696054e39 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.2377137820e20 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.2377137820e20 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + l__2 ^ 8 * m__2 ^ 4 + 0.3531740136e38
* J__1zz ^ 2 * J__2zz ^ 2 + 0.3531740136e38 * J__2xx ^
2 * J__2zz ^ 2 + J__2yy ^ 2 * J__2zz ^ 2)
-0.3531740136e10 * (0.1682695873e10 * J__2zz ^ 2 * r__m
* J__2yy * b__1 + 0.1000000000e29 * J__2zz ^ 2 * r__m *
J__1zz * b__1 + 0.1000000000e29 * J__2zz ^ 2 * r__m *
J__2xx * b__1 + 0.1682695873e10 * m__2 ^ 3 * l__2 ^ 6 *
b__1 * r__m + 0.1000000000e29 * m__2 * J__2zz ^ 2 * L__1
^ 2 * eta__g * eta__m * k__g ^ 2 * k__m * k__t +
0.1000000000e29 * J__2zz ^ 2 * eta__m * eta__g * k__t *
k__g ^ 2 * k__m * l__1 ^ 2 * m__1 + 0.3365391746e10 *
m__2 ^ 2 * l__2 ^ 4 * J__2zz * eta__m * eta__g * k__g ^
2 * k__m * k__t + 0.1000000000e29 * m__2 ^ 2 * l__2 ^ 4
* eta__m * eta__g * k__t * k__g ^ 2 * J__2xx * k__m +
0.1682695873e10 * m__2 ^ 2 * l__2 ^ 4 * eta__m * eta__g
* k__t * k__g ^ 2 * J__2yy * k__m + 0.1000000000e29 *
m__2 ^ 2 * l__2 ^ 4 * eta__m * eta__g * k__t * k__g ^ 2
* J__1zz * k__m + 0.1682695873e10 * m__2 * l__2 ^ 2 *
J__2zz ^ 2 * eta__m * eta__g * k__g ^ 2 * k__m * k__t +
```

```
0.1682695873e10 * m__2 ^ 3 * l__2 ^ 6 * eta__m * eta__g
* k__g ^ 2 * k__m * k__t + 0.2000000000e29 * m__2 *
l__2 ^ 2 * J__2zz * r__m * b__1 * l__1 ^ 2 * m__1 +
0.3365391746e10 * m__2 ^ 2 * l__2 ^ 4 * J__2zz * b__1 *
r__m + 0.1682695873e10 * m__2 ^ 2 * l__2 ^ 4 * r__m *
J__2yy * b__1 + 0.1000000000e29 * m__2 ^ 2 * l__2 ^ 4 *
r__m * J__1zz * b__1 + 0.1000000000e29 * m__2 ^ 2 *
l__2 ^ 4 * r__m * J__2xx * b__1 + 0.1000000000e29 *
m__2 * J__2zz ^ 2 * L__1 ^ 2 * b__1 * r__m +
0.1682695873e10 * m__2 * l__2 ^ 2 * J__2zz ^ 2 * b__1 *
r__m + 0.1000000000e29 * J__2zz ^ 2 * r__m * b__1 *
l__1 ^ 2 * m__1 + 0.2000000000e29 * m__2 * l__2 ^ 2 *
J__2zz * r__m * J__2xx * b__1 + 0.3365391746e10 * m__2 *
l__2 ^ 2 * J__2zz * r__m * J__2yy * b__1 +
0.2000000000e29 * m__2 * l__2 ^ 2 * J__2zz * r__m *
J__1zz * b__1 + 0.1000000000e29 * m__2 ^ 2 * J__2zz *
l__2 ^ 2 * L__1 ^ 2 * b__1 * r__m + 0.1000000000e29 *
m__2 ^ 2 * l__2 ^ 4 * r__m * b__1 * l__1 ^ 2 * m__1 +
0.1000000000e29 * m__2 ^ 2 * l__2 ^ 4 * eta__m * eta__g
* k__t * k__g ^ 2 * k__m * l__1 ^ 2 * m__1 +
0.3365391746e10 * m__2 * l__2 ^ 2 * J__2zz * eta__m *
eta__g * k__t * k__g ^ 2 * J__2yy * k__m +
0.2000000000e29 * m__2 * l__2 ^ 2 * J__2zz * eta__m *
eta__g * k__t * k__g ^ 2 * J__1zz * k__m +
0.2000000000e29 * m__2 * l__2 ^ 2 * J__2zz * eta__m *
eta__g * k__t * k__g ^ 2 * J__2xx * k__m +
0.1000000000e29 * m__2 ^ 2 * J__2zz * l__2 ^ 2 * eta__m
* eta__g * L__1 ^ 2 * k__g ^ 2 * k__m * k__t +
0.2000000000e29 * m__2 * l__2 ^ 2 * J__2zz * eta__m *
eta__g * k__t * k__g ^ 2 * k__m * l__1 ^ 2 * m__1 +
0.1000000000e29 * J__2zz ^ 2 * eta__m * eta__g * k__t *
k__g ^ 2 * J__2xx * k__m + 0.1682695873e10 * J__2zz ^ 2
* eta__m * eta__g * k__t * k__g ^ 2 * J__2yy * k__m +
0.1000000000e29 * J__2zz ^ 2 * eta__m * eta__g * k__t *
k__g ^ 2 * J__1zz * k__m) / r__m / (0.3531740136e38 *
l__1 ^ 4 * l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * l__1 ^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3
+ 0.1188568910e20 * J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2
^ 3 + 0.7063480271e38 * J__1zz * J__2xx * l__2 ^ 4 *
m__2 ^ 2 + 0.1188568910e20 * J__1zz * J__2yy * l__2 ^ 4
* m__2 ^ 2 + 0.2377137820e20 * J__1zz * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.1188568910e20 * J__2xx * J__2yy * l__2
^ 4 * m__2 ^ 2 + 0.2377137820e20 * J__2xx * J__2zz *
l__2 ^ 4 * m__2 ^ 2 + 0.4e1 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.1188568910e20 * J__2zz ^ 2 * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.7063480271e38 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.7063480271e38 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.1188568910e20 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.7063480271e38
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.7063480271e38 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.7063480271e38 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
m__1 + 0.1188568910e20 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.2e1 * J__2yy ^ 2 * J__2zz * l__2 ^ 2 * m__2
+ 0.1188568910e20 * J__2yy * J__2zz ^ 2 * L__1 ^ 2 *
m__2 + 0.1188568910e20 * J__2yy * J__2zz ^ 2 * l__1 ^ 2
```

```
* m__1 + 0.2e1 * J__2yy * J__2zz ^ 2 * l__2 ^ 2 * m__2
+ 0.1188568910e20 * J__1zz * l__2 ^ 6 * m__2 ^ 3 +
0.1188568910e20 * J__2xx * l__2 ^ 6 * m__2 ^ 3 + 0.2e1
* J__2yy * l__2 ^ 6 * m__2 ^ 3 + 0.2e1 * J__2zz * l__2 ^
6 * m__2 ^ 3 + 0.3531740136e38 * J__1zz ^ 2 * l__2 ^ 4
* m__2 ^ 2 + 0.3531740136e38 * J__2xx ^ 2 * l__2 ^ 4 *
m__2 ^ 2 + J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.3531740136e38 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.3531740136e38 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 + 0.7063480271e38 *
J__1zz * J__2xx * J__2zz ^ 2 + 0.1188568910e20 * J__1zz
* J__2yy * J__2zz ^ 2 + 0.1188568910e20 * J__2xx *
J__2yy * J__2zz ^ 2 + 0.7063480271e38 * J__2zz * L__1 ^
2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 +
0.1412696054e39 * J__1zz * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.1412696054e39 * J__2xx * J__2zz *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.2377137820e20 *
J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.7063480271e38 * J__1zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__2xx * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.1188568910e20 * J__2yy * l__1 ^
2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.7063480271e38 *
J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^ 2 * m__2 +
0.2377137820e20 * J__2zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__1zz * J__2zz * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__2xx *
J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.7063480271e38 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.1188568910e20 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.1412696054e39 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.2377137820e20 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.2377137820e20 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + l__2 ^ 8 * m__2 ^ 4 + 0.3531740136e38
* J__1zz ^ 2 * J__2zz ^ 2 + 0.3531740136e38 * J__2xx ^
2 * J__2zz ^ 2 + J__2yy ^ 2 * J__2zz ^ 2)
-0.3531740136e10 * (0.1000000000e29 * m__2 * L__1 * r__m
* J__2zz * l__2 * b__2 * l__1 ^ 2 * m__1 +
0.1682695873e10 * m__2 ^ 2 * l__2 ^ 3 * L__1 * r__m *
J__2yy * b__2 + 0.1000000000e29 * m__2 ^ 2 * l__2 ^ 3 *
L__1 * r__m * b__2 * J__1zz + 0.1000000000e29 * m__2 ^
2 * L__1 ^ 3 * r__m * J__2zz * l__2 * b__2 +
0.1682695873e10 * m__2 ^ 2 * l__2 ^ 3 * L__1 * r__m *
J__2zz * b__2 + 0.1000000000e29 * m__2 ^ 2 * l__2 ^ 3 *
L__1 * r__m * J__2xx * b__2 + 0.1682695873e10 * m__2 ^
3 * L__1 * r__m * l__2 ^ 5 * b__2 + 0.1000000000e29 *
m__2 ^ 2 * l__2 ^ 3 * L__1 * r__m * b__2 * l__1 ^ 2 *
m__1 + 0.1000000000e29 * m__2 * L__1 * r__m * J__2zz *
l__2 * b__2 * J__1zz + 0.1000000000e29 * m__2 * L__1 *
r__m * J__2zz * l__2 * J__2xx * b__2 + 0.1682695873e10
* m__2 * L__1 * r__m * J__2zz * l__2 * J__2yy * b__2) /
r__m / (0.3531740136e38 * l__1 ^ 4 * l__2 ^ 4 * m__1 ^
2 * m__2 ^ 2 + 0.1188568910e20 * l__1 ^ 2 * l__2 ^ 6 *
m__1 * m__2 ^ 3 + 0.1188568910e20 * J__2zz * L__1 ^ 2 *
l__2 ^ 4 * m__2 ^ 3 + 0.7063480271e38 * J__1zz * J__2xx
* l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20 * J__1zz *
```

```
J__2yy * l__2 ^ 4 * m__2 ^ 2 + 0.2377137820e20 * J__1zz
* J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20 *
J__2xx * J__2yy * l__2 ^ 4 * m__2 ^ 2 + 0.2377137820e20
* J__2xx * J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.4e1 *
J__2yy * J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20
* J__2zz ^ 2 * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.7063480271e38 * J__1zz ^ 2 * J__2zz * l__2 ^ 2 * m__2
+ 0.7063480271e38 * J__1zz * J__2zz ^ 2 * L__1 ^ 2 *
m__2 + 0.7063480271e38 * J__1zz * J__2zz ^ 2 * l__1 ^ 2
* m__1 + 0.1188568910e20 * J__1zz * J__2zz ^ 2 * l__2 ^
2 * m__2 + 0.7063480271e38 * J__2xx ^ 2 * J__2zz * l__2
^ 2 * m__2 + 0.7063480271e38 * J__2xx * J__2zz ^ 2 *
L__1 ^ 2 * m__2 + 0.7063480271e38 * J__2xx * J__2zz ^ 2
* l__1 ^ 2 * m__1 + 0.1188568910e20 * J__2xx * J__2zz ^
2 * l__2 ^ 2 * m__2 + 0.2e1 * J__2yy ^ 2 * J__2zz *
l__2 ^ 2 * m__2 + 0.1188568910e20 * J__2yy * J__2zz ^ 2
* L__1 ^ 2 * m__2 + 0.1188568910e20 * J__2yy * J__2zz ^
2 * l__1 ^ 2 * m__1 + 0.2e1 * J__2yy * J__2zz ^ 2 *
l__2 ^ 2 * m__2 + 0.1188568910e20 * J__1zz * l__2 ^ 6 *
m__2 ^ 3 + 0.1188568910e20 * J__2xx * l__2 ^ 6 * m__2 ^
3 + 0.2e1 * J__2yy * l__2 ^ 6 * m__2 ^ 3 + 0.2e1 *
J__2zz * l__2 ^ 6 * m__2 ^ 3 + 0.3531740136e38 * J__1zz
^ 2 * l__2 ^ 4 * m__2 ^ 2 + 0.3531740136e38 * J__2xx ^
2 * l__2 ^ 4 * m__2 ^ 2 + J__2yy ^ 2 * l__2 ^ 4 * m__2 ^
2 + 0.3531740136e38 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2
+ 0.3531740136e38 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 + 0.7063480271e38 *
J__1zz * J__2xx * J__2zz ^ 2 + 0.1188568910e20 * J__1zz
* J__2yy * J__2zz ^ 2 + 0.1188568910e20 * J__2xx *
J__2yy * J__2zz ^ 2 + 0.7063480271e38 * J__2zz * L__1 ^
2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 +
0.1412696054e39 * J__1zz * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.1412696054e39 * J__2xx * J__2zz *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.2377137820e20 *
J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.7063480271e38 * J__1zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__2xx * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.1188568910e20 * J__2yy * l__1 ^
2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.7063480271e38 *
J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^ 2 * m__2 +
0.2377137820e20 * J__2zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__1zz * J__2zz * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__2xx *
J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.7063480271e38 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.1188568910e20 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.1412696054e39 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.2377137820e20 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.2377137820e20 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + l__2 ^ 8 * m__2 ^ 4 + 0.3531740136e38
* J__1zz ^ 2 * J__2zz ^ 2 + 0.3531740136e38 * J__2xx ^ 2
* J__2zz ^ 2 + J__2yy ^ 2 * J__2zz ^ 2); 0
-0.5000000000e-9 / r__m / (0.1000000000e57 * l__1 ^ 4 *
l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 + 0.3365391746e38 * l__1
^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3 + 0.3365391746e38 *
```

```
J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2 ^ 3 +
0.2000000000e57 * J__1zz * J__2xx * l__2 ^ 4 * m__2 ^ 2
+ 0.3365391746e38 * J__1zz * J__2yy * l__2 ^ 4 * m__2 ^
2 + 0.6730783492e38 * J__1zz * J__2zz * l__2 ^ 4 * m__2
^ 2 + 0.3365391746e38 * J__2xx * J__2yy * l__2 ^ 4 *
m__2 ^ 2 + 0.6730783492e38 * J__2xx * J__2zz * l__2 ^ 4
* m__2 ^ 2 + 0.1132586160e20 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.3365391746e38 * J__2zz ^ 2 * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.2000000000e57 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.2000000000e57 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.3365391746e38 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.2000000000e57
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.2000000000e57 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.2000000000e57 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
m__1 + 0.3365391746e38 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.5662930802e19 * J__2yy ^ 2 * J__2zz * l__2 ^
2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 * L__1
^ 2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 *
l__1 ^ 2 * m__1 + 0.5662930802e19 * J__2yy * J__2zz ^ 2
* l__2 ^ 2 * m__2 + 0.3365391746e38 * J__1zz * l__2 ^ 6
* m__2 ^ 3 + 0.3365391746e38 * J__2xx * l__2 ^ 6 * m__2
^ 3 + 0.5662930802e19 * J__2yy * l__2 ^ 6 * m__2 ^ 3 +
0.5662930802e19 * J__2zz * l__2 ^ 6 * m__2 ^ 3 +
0.1000000000e57 * J__1zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
0.2831465401e19 * J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2000000000e57 * J__1zz * J__2xx * J__2zz ^ 2 +
0.3365391746e38 * J__1zz * J__2yy * J__2zz ^ 2 +
0.3365391746e38 * J__2xx * J__2yy * J__2zz ^ 2 +
0.2000000000e57 * J__2zz * L__1 ^ 2 * l__1 ^ 2 * l__2 ^
2 * m__1 * m__2 ^ 2 + 0.4000000000e57 * J__1zz * J__2zz
* l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__2xx * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.6730783492e38 * J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.2000000000e57 * J__1zz * l__1 ^ 2 *
l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__2xx *
l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.3365391746e38
* J__2yy * l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 +
0.2000000000e57 * J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^
2 * m__2 + 0.6730783492e38 * J__2zz * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__1zz * J__2zz
* L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 *
J__2xx * J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.3365391746e38 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.2000000000e57 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.3365391746e38 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.6730783492e38 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.6730783492e38 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + 0.2831465401e19 * l__2 ^ 8 * m__2 ^ 4
+ 0.1000000000e57 * J__1zz ^ 2 * J__2zz ^ 2 +
```

```
0.1000000000e57 * J__2xx ^ 2 * J__2zz ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * J__2zz ^ 2) *
(-0.5662930809e28 * g * l__2 ^ 7 * m__2 ^ 4 * r__m +
0.1640827046e57 * L__1 ^ 3 * V__m * eta__g * eta__m *
k__g * k__t * l__2 ^ 3 * m__2 ^ 3 + 0.8204135230e56 *
J__2zz * L__1 * V__m * eta__g * eta__m * k__g * k__t *
l__1 ^ 2 * l__2 * m__1 * m__2 + 0.1640827046e57 * L__1
^ 2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 * r__m *
tau__2 - 0.3999999999e66 * J__1zz * J__2zz * L__1 ^ 2 *
g * l__2 * m__2 ^ 2 * r__m - 0.3999999999e66 * J__2xx *
J__2zz * L__1 ^ 2 * g * l__2 * m__2 ^ 2 * r__m -
0.6730783497e47 * J__2yy * J__2zz * L__1 ^ 2 * g * l__2
* m__2 ^ 2 * r__m - 0.3999999999e66 * J__1zz * J__2xx *
J__2zz * g * l__2 * m__2 * r__m - 0.6730783497e47 *
J__1zz * J__2yy * J__2zz * g * l__2 * m__2 * r__m -
0.6730783497e47 * J__2xx * J__2yy * J__2zz * g * l__2 *
m__2 * r__m - 0.2000000000e66 * L__1 ^ 2 * g * l__1 ^ 2
* l__2 ^ 3 * m__1 * m__2 ^ 3 * r__m - 0.3999999999e66 *
J__1zz * g * l__1 ^ 2 * l__2 ^ 3 * m__1 * m__2 ^ 2 *
r__m - 0.3999999999e66 * J__2xx * g * l__1 ^ 2 * l__2 ^
3 * m__1 * m__2 ^ 2 * r__m - 0.6730783497e47 * J__2yy *
g * l__1 ^ 2 * l__2 ^ 3 * m__1 * m__2 ^ 2 * r__m -
0.2000000000e66 * J__2zz * g * l__1 ^ 4 * l__2 * m__1 ^
2 * m__2 * r__m - 0.6730783497e47 * J__2zz * g * l__1 ^
2 * l__2 ^ 3 * m__1 * m__2 ^ 2 * r__m + 0.8204135230e56
* J__1zz * L__1 * V__m * eta__g * eta__m * k__g * k__t
* l__2 ^ 3 * m__2 ^ 2 - 0.8204135230e56 * J__2xx * L__1
* V__m * eta__g * eta__m * k__g * k__t * l__2 ^ 3 *
m__2 ^ 2 + 0.1640827046e57 * J__2yy * L__1 * V__m *
eta__g * eta__m * k__g * k__t * l__2 ^ 3 * m__2 ^ 2 +
0.8204135230e56 * J__2zz * L__1 ^ 3 * V__m * eta__g *
eta__m * k__g * k__t * l__2 * m__2 ^ 2 +
0.1640827046e57 * J__2zz * L__1 * V__m * eta__g *
eta__m * k__g * k__t * l__2 ^ 3 * m__2 ^ 2 -
0.5662930809e28 * J__2yy ^ 2 * J__2zz * g * l__2 * m__2
* r__m - 0.2000000000e66 * g * l__1 ^ 4 * l__2 ^ 3 *
m__1 ^ 2 * m__2 ^ 2 * r__m - 0.6730783497e47 * g * l__1
^ 2 * l__2 ^ 5 * m__1 * m__2 ^ 3 * r__m -
0.2000000000e66 * J__1zz * L__1 ^ 2 * g * l__2 ^ 3 *
m__2 ^ 3 * r__m - 0.2000000000e66 * J__2xx * L__1 ^ 2 *
g * l__2 ^ 3 * m__2 ^ 3 * r__m + 0.3365391744e47 *
J__2yy * L__1 ^ 2 * g * l__2 ^ 3 * m__2 ^ 3 * r__m -
0.2000000000e66 * J__2zz * L__1 ^ 4 * g * l__2 * m__2 ^
3 * r__m - 0.6730783497e47 * J__2zz * L__1 ^ 2 * g *
l__2 ^ 3 * m__2 ^ 3 * r__m - 0.3999999999e66 * J__1zz *
J__2xx * g * l__2 ^ 3 * m__2 ^ 2 * r__m -
0.6730783497e47 * J__1zz * J__2yy * g * l__2 ^ 3 * m__2
^ 2 * r__m - 0.6730783497e47 * J__1zz * J__2zz * g *
l__2 ^ 3 * m__2 ^ 2 * r__m + 0.1640827046e57 * J__1zz *
L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 * r__m * tau__2 -
0.6730783497e47 * J__2xx * J__2yy * g * l__2 ^ 3 * m__2
^ 2 * r__m - 0.6730783497e47 * J__2xx * J__2zz * g *
l__2 ^ 3 * m__2 ^ 2 * r__m - 0.1132586162e29 * J__2yy *
J__2zz * g * l__2 ^ 3 * m__2 ^ 2 * r__m +
0.1640827046e57 * J__2yy * L__1 ^ 2 * l__2 ^ 2 * m__2 ^
2 * r__m * tau__2 - 0.2000000000e66 * J__1zz ^ 2 *
J__2zz * g * l__2 * m__2 * r__m - 0.2000000000e66 *
```

```
J__2xx ^ 2 * J__2zz * g * l__2 * m__2 * r__m +
0.6730783489e47 * L__1 ^ 4 * g * l__2 ^ 3 * m__2 ^ 4 *
r__m + 0.1640827046e57 * L__1 ^ 4 * l__2 ^ 2 * m__2 ^ 3
* r__m * tau__2 + 0.1640827046e57 * L__1 * V__m *
eta__g * eta__m * k__g * k__t * l__2 ^ 5 * m__2 ^ 3 -
0.3999999999e66 * J__2zz * L__1 ^ 2 * g * l__1 ^ 2 *
l__2 * m__1 * m__2 ^ 2 * r__m - 0.3999999999e66 *
J__1zz * J__2zz * g * l__1 ^ 2 * l__2 * m__1 * m__2 *
r__m - 0.3999999999e66 * J__2xx * J__2zz * g * l__1 ^ 2
* l__2 * m__1 * m__2 * r__m - 0.6730783497e47 * J__2yy
* J__2zz * g * l__1 ^ 2 * l__2 * m__1 * m__2 * r__m +
0.3365391744e47 * L__1 ^ 2 * g * l__2 ^ 5 * m__2 ^ 4 *
r__m - 0.6730783497e47 * J__1zz * g * l__2 ^ 5 * m__2 ^
3 * r__m - 0.6730783497e47 * J__2xx * g * l__2 ^ 5 *
m__2 ^ 3 * r__m - 0.1132586162e29 * J__2yy * g * l__2 ^
5 * m__2 ^ 3 * r__m - 0.5662930809e28 * J__2zz * g *
l__2 ^ 5 * m__2 ^ 3 * r__m + 0.1640827046e57 * L__1 ^ 2
* l__2 ^ 4 * m__2 ^ 3 * r__m * tau__2 - 0.2000000000e66
* J__1zz ^ 2 * g * l__2 ^ 3 * m__2 ^ 2 * r__m -
0.2000000000e66 * J__2xx ^ 2 * g * l__2 ^ 3 * m__2 ^ 2
* r__m - 0.5662930809e28 * J__2yy ^ 2 * g * l__2 ^ 3 *
m__2 ^ 2 * r__m + 0.8204135230e56 * L__1 * V__m *
eta__g * eta__m * k__g * k__t * l__1 ^ 2 * l__2 ^ 3 *
m__1 * m__2 ^ 2 + 0.8204135230e56 * J__1zz * J__2zz *
L__1 * V__m * eta__g * eta__m * k__g * k__t * l__2 *
m__2 - 0.8204135230e56 * J__2xx * J__2zz * L__1 * V__m *
eta__g * eta__m * k__g * k__t * l__2 * m__2 +
0.1640827046e57 * J__2yy * J__2zz * L__1 * V__m *
eta__g * eta__m * k__g * k__t * l__2 * m__2)
-0.5000000000e-9 / r__m / (0.1000000000e57 * l__1 ^ 4 *
l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 + 0.3365391746e38 * l__1
^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3 + 0.3365391746e38 *
J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2 ^ 3 +
0.2000000000e57 * J__1zz * J__2xx * l__2 ^ 4 * m__2 ^ 2
+ 0.3365391746e38 * J__1zz * J__2yy * l__2 ^ 4 * m__2 ^
2 + 0.6730783492e38 * J__1zz * J__2zz * l__2 ^ 4 * m__2
^ 2 + 0.3365391746e38 * J__2xx * J__2yy * l__2 ^ 4 *
m__2 ^ 2 + 0.6730783492e38 * J__2xx * J__2zz * l__2 ^ 4
* m__2 ^ 2 + 0.1132586160e20 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.3365391746e38 * J__2zz ^ 2 * L__1 ^ 2 *
l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.2000000000e57 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.2000000000e57 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.3365391746e38 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.2000000000e57
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.2000000000e57 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.2000000000e57 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
m__1 + 0.3365391746e38 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.5662930802e19 * J__2yy ^ 2 * J__2zz * l__2 ^
2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 * L__1
^ 2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 *
l__1 ^ 2 * m__1 + 0.5662930802e19 * J__2yy * J__2zz ^ 2
* l__2 ^ 2 * m__2 + 0.3365391746e38 * J__1zz * l__2 ^ 6
* m__2 ^ 3 + 0.3365391746e38 * J__2xx * l__2 ^ 6 * m__2
^ 3 + 0.5662930802e19 * J__2yy * l__2 ^ 6 * m__2 ^ 3 +
0.5662930802e19 * J__2zz * l__2 ^ 6 * m__2 ^ 3 +
```

```
0.1000000000e57 * J__1zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
0.2831465401e19 * J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2000000000e57 * J__1zz * J__2xx * J__2zz ^ 2 +
0.3365391746e38 * J__1zz * J__2yy * J__2zz ^ 2 +
0.3365391746e38 * J__2xx * J__2yy * J__2zz ^ 2 +
0.2000000000e57 * J__2zz * L__1 ^ 2 * l__1 ^ 2 * l__2 ^
2 * m__1 * m__2 ^ 2 + 0.4000000000e57 * J__1zz * J__2zz
* l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__2xx * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.6730783492e38 * J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.2000000000e57 * J__1zz * l__1 ^ 2 *
l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__2xx *
l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.3365391746e38
* J__2yy * l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 +
0.2000000000e57 * J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^
2 * m__2 + 0.6730783492e38 * J__2zz * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__1zz * J__2zz
* L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 *
J__2xx * J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.3365391746e38 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.2000000000e57 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.3365391746e38 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.6730783492e38 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.6730783492e38 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + 0.2831465401e19 * l__2 ^ 8 * m__2 ^ 4
+ 0.1000000000e57 * J__1zz ^ 2 * J__2zz ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * J__2zz ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * J__2zz ^ 2) *
(0.2000000000e66 * L__1 * eta__g * eta__m * k__g ^ 2 *
k__m * k__t * l__1 ^ 2 * l__2 ^ 3 * m__1 * m__2 ^ 2 +
0.2000000000e66 * J__1zz * J__2zz * L__1 * eta__g *
eta__m * k__g ^ 2 * k__m * k__t * l__2 * m__2 +
0.2000000000e66 * J__2xx * J__2zz * L__1 * eta__g *
eta__m * k__g ^ 2 * k__m * k__t * l__2 * m__2 +
0.3365391746e47 * J__2yy * J__2zz * L__1 * eta__g *
eta__m * k__g ^ 2 * k__m * k__t * l__2 * m__2 +
0.3365391746e47 * L__1 * eta__g * eta__m * k__g ^ 2 *
k__m * k__t * l__2 ^ 5 * m__2 ^ 3 + 0.2000000000e66 *
J__2zz * L__1 * b__1 * l__1 ^ 2 * l__2 * m__1 * m__2 *
r__m + 0.3365391746e47 * L__1 * b__1 * l__2 ^ 5 * m__2
^ 3 * r__m + 0.2000000000e66 * J__2zz * L__1 * eta__g *
eta__m * k__g ^ 2 * k__m * k__t * l__1 ^ 2 * l__2 *
m__1 * m__2 + 0.2000000000e66 * L__1 * b__1 * l__1 ^ 2
* l__2 ^ 3 * m__1 * m__2 ^ 2 * r__m + 0.2000000000e66 *
J__1zz * J__2zz * L__1 * b__1 * l__2 * m__2 * r__m +
0.2000000000e66 * J__2xx * J__2zz * L__1 * b__1 * l__2
* m__2 * r__m + 0.3365391746e47 * J__2yy * J__2zz *
L__1 * b__1 * l__2 * m__2 * r__m + 0.2000000000e66 *
J__2zz * L__1 ^ 3 * b__1 * l__2 * m__2 ^ 2 * r__m +
0.3365391746e47 * J__2zz * L__1 * b__1 * l__2 ^ 3 * m__2
^ 2 * r__m + 0.2000000000e66 * J__1zz * L__1 * b__1 *
```

```
l__2 ^ 3 * m__2 ^ 2 * r__m + 0.2000000000e66 * J__2xx *
L__1 * b__1 * l__2 ^ 3 * m__2 ^ 2 * r__m +
0.3365391746e47 * J__2yy * L__1 * b__1 * l__2 ^ 3 * m__2
^ 2 * r__m + 0.3365391746e47 * J__2zz * L__1 * eta__g *
eta__m * k__g ^ 2 * k__m * k__t * l__2 ^ 3 * m__2 ^ 2 +
0.2000000000e66 * J__1zz * L__1 * eta__g * eta__m *
k__g ^ 2 * k__m * k__t * l__2 ^ 3 * m__2 ^ 2 +
0.2000000000e66 * J__2xx * L__1 * eta__g * eta__m * k__g
^ 2 * k__m * k__t * l__2 ^ 3 * m__2 ^ 2 +
0.3365391746e47 * J__2yy * L__1 * eta__g * eta__m *
k__g ^ 2 * k__m * k__t * l__2 ^ 3 * m__2 ^ 2 +
0.2000000000e66 * J__2zz * L__1 ^ 3 * eta__g * eta__m *
k__g ^ 2 * k__m * k__t * l__2 * m__2 ^ 2)
-0.5000000000e-9 / r__m / (0.1000000000e57 * l__1 ^ 4 *
l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 + 0.3365391746e38 * l__1
^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3 + 0.3365391746e38 *
J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2 ^ 3 +
0.2000000000e57 * J__1zz * J__2xx * l__2 ^ 4 * m__2 ^ 2
+ 0.3365391746e38 * J__1zz * J__2yy * l__2 ^ 4 * m__2 ^
2 + 0.6730783492e38 * J__1zz * J__2zz * l__2 ^ 4 * m__2
^ 2 + 0.3365391746e38 * J__2xx * J__2yy * l__2 ^ 4 *
m__2 ^ 2 + 0.6730783492e38 * J__2xx * J__2zz * l__2 ^ 4
* m__2 ^ 2 + 0.1132586160e20 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.3365391746e38 * J__2zz ^ 2 * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.2000000000e57 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.2000000000e57 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.3365391746e38 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.2000000000e57
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.2000000000e57 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.2000000000e57 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
m__1 + 0.3365391746e38 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.5662930802e19 * J__2yy ^ 2 * J__2zz * l__2 ^
2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 * L__1
^ 2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 *
l__1 ^ 2 * m__1 + 0.5662930802e19 * J__2yy * J__2zz ^ 2
* l__2 ^ 2 * m__2 + 0.3365391746e38 * J__1zz * l__2 ^ 6
* m__2 ^ 3 + 0.3365391746e38 * J__2xx * l__2 ^ 6 * m__2
^ 3 + 0.5662930802e19 * J__2yy * l__2 ^ 6 * m__2 ^ 3 +
0.5662930802e19 * J__2zz * l__2 ^ 6 * m__2 ^ 3 +
0.1000000000e57 * J__1zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
0.2831465401e19 * J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2000000000e57 * J__1zz * J__2xx * J__2zz ^ 2 +
0.3365391746e38 * J__1zz * J__2yy * J__2zz ^ 2 +
0.3365391746e38 * J__2xx * J__2yy * J__2zz ^ 2 +
0.2000000000e57 * J__2zz * L__1 ^ 2 * l__1 ^ 2 * l__2 ^
2 * m__1 * m__2 ^ 2 + 0.4000000000e57 * J__1zz * J__2zz
* l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__2xx * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.6730783492e38 * J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.2000000000e57 * J__1zz * l__1 ^ 2 *
l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__2xx *
```

```
l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.3365391746e38
* J__2yy * l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 +
0.2000000000e57 * J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^
2 * m__2 + 0.6730783492e38 * J__2zz * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__1zz * J__2zz
* L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 *
J__2xx * J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.3365391746e38 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.2000000000e57 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.3365391746e38 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.6730783492e38 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.6730783492e38 * J__2xx * J__2yy * J__2zz * l__2
^ 2 * m__2 + 0.2831465401e19 * l__2 ^ 8 * m__2 ^ 4 +
0.1000000000e57 * J__1zz ^ 2 * J__2zz ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * J__2zz ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * J__2zz ^ 2) *
(0.5662930802e28 * b__2 * l__2 ^ 6 * m__2 ^ 3 * r__m +
0.2000000000e66 * J__1zz ^ 2 * J__2zz * b__2 * r__m +
0.2000000000e66 * J__2xx ^ 2 * J__2zz * b__2 * r__m +
0.5662930802e28 * J__2yy ^ 2 * J__2zz * b__2 * r__m +
0.6730783492e47 * J__1zz * J__2yy * J__2zz * b__2 *
r__m + 0.6730783492e47 * J__2xx * J__2yy * J__2zz * b__2
* r__m + 0.3365391746e47 * L__1 ^ 2 * b__2 * l__2 ^ 4 *
m__2 ^ 3 * r__m + 0.6730783492e47 * J__1zz * b__2 *
l__2 ^ 4 * m__2 ^ 2 * r__m + 0.6730783492e47 * J__2xx *
b__2 * l__2 ^ 4 * m__2 ^ 2 * r__m + 0.1132586160e29 *
J__2yy * b__2 * l__2 ^ 4 * m__2 ^ 2 * r__m +
0.2000000000e66 * J__2zz * L__1 ^ 4 * b__2 * m__2 ^ 2 *
r__m + 0.2000000000e66 * J__2zz * b__2 * l__1 ^ 4 *
m__1 ^ 2 * r__m + 0.5662930802e28 * J__2zz * b__2 *
l__2 ^ 4 * m__2 ^ 2 * r__m + 0.2000000000e66 * J__1zz ^
2 * b__2 * l__2 ^ 2 * m__2 * r__m + 0.2000000000e66 *
J__2xx ^ 2 * b__2 * l__2 ^ 2 * m__2 * r__m +
0.5662930802e28 * J__2yy ^ 2 * b__2 * l__2 ^ 2 * m__2 *
r__m + 0.4000000000e66 * J__1zz * J__2xx * J__2zz *
b__2 * r__m + 0.2000000000e66 * b__2 * l__1 ^ 4 * l__2 ^
2 * m__1 ^ 2 * m__2 * r__m + 0.6730783492e47 * b__2 *
l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 * r__m +
0.2000000000e66 * J__1zz * L__1 ^ 2 * b__2 * l__2 ^ 2 *
m__2 ^ 2 * r__m + 0.2000000000e66 * J__2xx * L__1 ^ 2 *
b__2 * l__2 ^ 2 * m__2 ^ 2 * r__m + 0.3365391746e47 *
J__2yy * L__1 ^ 2 * b__2 * l__2 ^ 2 * m__2 ^ 2 * r__m +
0.6730783492e47 * J__2zz * L__1 ^ 2 * b__2 * l__2 ^ 2 *
m__2 ^ 2 * r__m + 0.4000000000e66 * J__1zz * J__2xx *
b__2 * l__2 ^ 2 * m__2 * r__m + 0.6730783492e47 *
J__1zz * J__2yy * b__2 * l__2 ^ 2 * m__2 * r__m +
0.4000000000e66 * J__1zz * J__2zz * L__1 ^ 2 * b__2 *
m__2 * r__m + 0.4000000000e66 * J__1zz * J__2zz * b__2
* l__1 ^ 2 * m__1 * r__m + 0.6730783492e47 * J__1zz *
J__2zz * b__2 * l__2 ^ 2 * m__2 * r__m + 0.6730783492e47
* J__2xx * J__2yy * b__2 * l__2 ^ 2 * m__2 * r__m +
0.4000000000e66 * J__2xx * J__2zz * L__1 ^ 2 * b__2 *
m__2 * r__m + 0.4000000000e66 * J__2xx * J__2zz * b__2
* l__1 ^ 2 * m__1 * r__m + 0.6730783492e47 * J__2xx *
J__2zz * b__2 * l__2 ^ 2 * m__2 * r__m + 0.6730783492e47
```

```
* J__2yy * J__2zz * L__1 ^ 2 * b__2 * m__2 * r__m +
0.6730783492e47 * J__2yy * J__2zz * b__2 * l__1 ^ 2 *
m__1 * r__m + 0.1132586160e29 * J__2yy * J__2zz * b__2
* l__2 ^ 2 * m__2 * r__m + 0.2000000000e66 * L__1 ^ 2 *
b__2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 * r__m +
0.4000000000e66 * J__1zz * b__2 * l__1 ^ 2 * l__2 ^ 2 *
m__1 * m__2 * r__m + 0.4000000000e66 * J__2xx * b__2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 * r__m +
0.6730783492e47 * J__2yy * b__2 * l__1 ^ 2 * l__2 ^ 2 *
m__1 * m__2 * r__m + 0.4000000000e66 * J__2zz * L__1 ^ 2
* b__2 * l__1 ^ 2 * m__1 * m__2 * r__m +
0.6730783492e47 * J__2zz * b__2 * l__1 ^ 2 * l__2 ^ 2 *
m__1 * m__2 * r__m);];
dtheta1_dt = [0 0 1 0; 0 0 0 1; 0 0.5998558162e2
-0.1613923708e2 0; 0 0.9615182815e2 -0.1469336136e2 0;]
;
> Matlab(B, resultname="B");
  Matlab(B_data, resultname="B");
B = [0; 0; 0.3531740136e10 * (-0.2000000000e29 * eta__g
* eta__m * k__g * k__t * l__2 ^ 2 * m__2 * J__2zz *
l__1 ^ 2 * m__1 - 0.2577405097e20 * eta__g * eta__m *
k__g * k__t * l__2 ^ 4 * m__2 ^ 3 * L__1 ^ 2 -
0.9999999974e28 * eta__g * eta__m * k__g * k__t * l__2 ^
4 * m__2 ^ 2 * J__2xx - 0.2577405097e20 * eta__g *
eta__m * k__g * k__t * l__2 ^ 4 * m__2 ^ 2 * J__2yy -
0.5154810194e20 * eta__g * eta__m * k__g * k__t * l__2
^ 4 * m__2 ^ 2 * J__2zz - 0.2577405097e20 * J__2zz ^ 2
* eta__g * eta__m * k__g * k__t * l__2 ^ 2 * m__2 -
0.1000000000e29 * eta__g * eta__m * k__g * k__t * l__2
^ 4 * m__2 ^ 2 * J__1zz - 0.1000000000e29 * J__2zz ^ 2
* eta__g * eta__m * k__g * k__t * L__1 ^ 2 * m__2 -
0.1000000000e29 * J__2zz ^ 2 * eta__g * eta__m * k__g *
k__t * l__1 ^ 2 * m__1 - 0.1000000000e29 * eta__g *
eta__m * k__g * k__t * l__2 ^ 4 * m__2 ^ 2 * l__1 ^ 2 *
m__1 - 0.2000000000e29 * eta__g * eta__m * k__g * k__t
* l__2 ^ 2 * m__2 * J__1zz * J__2zz - 0.1999999995e29 *
eta__g * eta__m * k__g * k__t * l__2 ^ 2 * m__2 * J__2xx
* J__2zz - 0.5154810194e20 * eta__g * eta__m * k__g *
k__t * l__2 ^ 2 * m__2 * J__2yy * J__2zz -
0.1000000003e29 * J__2zz * eta__g * eta__m * k__g *
k__t * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 - 0.1000000000e29
* J__2zz ^ 2 * eta__g * eta__m * k__g * k__t * J__1zz -
0.2577405097e20 * eta__g * eta__m * k__g * k__t * l__2
^ 6 * m__2 ^ 3 - 0.9999999974e28 * J__2zz ^ 2 * eta__g
* eta__m * k__g * k__t * J__2xx - 0.2577405097e20 *
J__2zz ^ 2 * eta__g * eta__m * k__g * k__t * J__2yy) /
r__m / (0.3531740136e38 * l__1 ^ 4 * l__2 ^ 4 * m__1 ^
2 * m__2 ^ 2 + 0.1188568910e20 * l__1 ^ 2 * l__2 ^ 6 *
m__1 * m__2 ^ 3 + 0.1188568910e20 * J__2zz * L__1 ^ 2 *
l__2 ^ 4 * m__2 ^ 3 + 0.7063480271e38 * J__1zz * J__2xx
* l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20 * J__1zz *
J__2yy * l__2 ^ 4 * m__2 ^ 2 + 0.2377137820e20 * J__1zz
* J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20 *
J__2xx * J__2yy * l__2 ^ 4 * m__2 ^ 2 + 0.2377137820e20
* J__2xx * J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.4e1 *
J__2yy * J__2zz * l__2 ^ 4 * m__2 ^ 2 + 0.1188568910e20
```

```
* J__2zz ^ 2 * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.7063480271e38 * J__1zz ^ 2 * J__2zz * l__2 ^ 2 * m__2
+ 0.7063480271e38 * J__1zz * J__2zz ^ 2 * L__1 ^ 2 *
m__2 + 0.7063480271e38 * J__1zz * J__2zz ^ 2 * l__1 ^ 2
* m__1 + 0.1188568910e20 * J__1zz * J__2zz ^ 2 * l__2 ^
2 * m__2 + 0.7063480271e38 * J__2xx ^ 2 * J__2zz * l__2
^ 2 * m__2 + 0.7063480271e38 * J__2xx * J__2zz ^ 2 *
L__1 ^ 2 * m__2 + 0.7063480271e38 * J__2xx * J__2zz ^ 2
* l__1 ^ 2 * m__1 + 0.1188568910e20 * J__2xx * J__2zz ^
2 * l__2 ^ 2 * m__2 + 0.2e1 * J__2yy ^ 2 * J__2zz * l__2
^ 2 * m__2 + 0.1188568910e20 * J__2yy * J__2zz ^ 2 *
L__1 ^ 2 * m__2 + 0.1188568910e20 * J__2yy * J__2zz ^ 2
* l__1 ^ 2 * m__1 + 0.2e1 * J__2yy * J__2zz ^ 2 * l__2
^ 2 * m__2 + 0.1188568910e20 * J__1zz * l__2 ^ 6 * m__2
^ 3 + 0.1188568910e20 * J__2xx * l__2 ^ 6 * m__2 ^ 3 +
0.2e1 * J__2yy * l__2 ^ 6 * m__2 ^ 3 + 0.2e1 * J__2zz *
l__2 ^ 6 * m__2 ^ 3 + 0.3531740136e38 * J__1zz ^ 2 *
l__2 ^ 4 * m__2 ^ 2 + 0.3531740136e38 * J__2xx ^ 2 *
l__2 ^ 4 * m__2 ^ 2 + J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2
+ 0.3531740136e38 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.3531740136e38 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 + 0.7063480271e38 *
J__1zz * J__2xx * J__2zz ^ 2 + 0.1188568910e20 * J__1zz
* J__2yy * J__2zz ^ 2 + 0.1188568910e20 * J__2xx *
J__2yy * J__2zz ^ 2 + 0.7063480271e38 * J__2zz * L__1 ^
2 * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 ^ 2 +
0.1412696054e39 * J__1zz * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.1412696054e39 * J__2xx * J__2zz *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.2377137820e20 *
J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.7063480271e38 * J__1zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__2xx * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.1188568910e20 * J__2yy * l__1 ^
2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.7063480271e38 *
J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^ 2 * m__2 +
0.2377137820e20 * J__2zz * l__1 ^ 2 * l__2 ^ 4 * m__1 *
m__2 ^ 2 + 0.7063480271e38 * J__1zz * J__2zz * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.7063480271e38 * J__2xx *
J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.1188568910e20 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.7063480271e38 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.1188568910e20 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.1412696054e39 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.2377137820e20 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.2377137820e20 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + l__2 ^ 8 * m__2 ^ 4 + 0.3531740136e38
* J__1zz ^ 2 * J__2zz ^ 2 + 0.3531740136e38 * J__2xx ^
2 * J__2zz ^ 2 + J__2yy ^ 2 * J__2zz ^ 2);
0.5000000000e-9 / r__m / (0.1000000000e57 * l__1 ^ 4 *
l__2 ^ 4 * m__1 ^ 2 * m__2 ^ 2 + 0.3365391746e38 * l__1
^ 2 * l__2 ^ 6 * m__1 * m__2 ^ 3 + 0.3365391746e38 *
J__2zz * L__1 ^ 2 * l__2 ^ 4 * m__2 ^ 3 +
0.2000000000e57 * J__1zz * J__2xx * l__2 ^ 4 * m__2 ^ 2
+ 0.3365391746e38 * J__1zz * J__2yy * l__2 ^ 4 * m__2 ^
2 + 0.6730783492e38 * J__1zz * J__2zz * l__2 ^ 4 * m__2
^ 2 + 0.3365391746e38 * J__2xx * J__2yy * l__2 ^ 4 *
```

```
m__2 ^ 2 + 0.6730783492e38 * J__2xx * J__2zz * l__2 ^ 4
* m__2 ^ 2 + 0.1132586160e20 * J__2yy * J__2zz * l__2 ^
4 * m__2 ^ 2 + 0.3365391746e38 * J__2zz ^ 2 * L__1 ^ 2
* l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 * J__1zz ^ 2 *
J__2zz * l__2 ^ 2 * m__2 + 0.2000000000e57 * J__1zz *
J__2zz ^ 2 * L__1 ^ 2 * m__2 + 0.2000000000e57 * J__1zz
* J__2zz ^ 2 * l__1 ^ 2 * m__1 + 0.3365391746e38 *
J__1zz * J__2zz ^ 2 * l__2 ^ 2 * m__2 + 0.2000000000e57
* J__2xx ^ 2 * J__2zz * l__2 ^ 2 * m__2 +
0.2000000000e57 * J__2xx * J__2zz ^ 2 * L__1 ^ 2 * m__2
+ 0.2000000000e57 * J__2xx * J__2zz ^ 2 * l__1 ^ 2 *
m__1 + 0.3365391746e38 * J__2xx * J__2zz ^ 2 * l__2 ^ 2
* m__2 + 0.5662930802e19 * J__2yy ^ 2 * J__2zz * l__2 ^
2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 * L__1
^ 2 * m__2 + 0.3365391746e38 * J__2yy * J__2zz ^ 2 *
l__1 ^ 2 * m__1 + 0.5662930802e19 * J__2yy * J__2zz ^ 2
* l__2 ^ 2 * m__2 + 0.3365391746e38 * J__1zz * l__2 ^ 6
* m__2 ^ 3 + 0.3365391746e38 * J__2xx * l__2 ^ 6 * m__2
^ 3 + 0.5662930802e19 * J__2yy * l__2 ^ 6 * m__2 ^ 3 +
0.5662930802e19 * J__2zz * l__2 ^ 6 * m__2 ^ 3 +
0.1000000000e57 * J__1zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * L__1 ^ 4 * m__2 ^ 2 +
0.1000000000e57 * J__2zz ^ 2 * l__1 ^ 4 * m__1 ^ 2 +
0.2831465401e19 * J__2zz ^ 2 * l__2 ^ 4 * m__2 ^ 2 +
0.2000000000e57 * J__1zz * J__2xx * J__2zz ^ 2 +
0.3365391746e38 * J__1zz * J__2yy * J__2zz ^ 2 +
0.3365391746e38 * J__2xx * J__2yy * J__2zz ^ 2 +
0.2000000000e57 * J__2zz * L__1 ^ 2 * l__1 ^ 2 * l__2 ^
2 * m__1 * m__2 ^ 2 + 0.4000000000e57 * J__1zz * J__2zz
* l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__2xx * J__2zz * l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 +
0.6730783492e38 * J__2yy * J__2zz * l__1 ^ 2 * l__2 ^ 2
* m__1 * m__2 + 0.2000000000e57 * J__1zz * l__1 ^ 2 *
l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__2xx *
l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 + 0.3365391746e38
* J__2yy * l__1 ^ 2 * l__2 ^ 4 * m__1 * m__2 ^ 2 +
0.2000000000e57 * J__2zz * l__1 ^ 4 * l__2 ^ 2 * m__1 ^
2 * m__2 + 0.6730783492e38 * J__2zz * l__1 ^ 2 * l__2 ^
4 * m__1 * m__2 ^ 2 + 0.2000000000e57 * J__1zz * J__2zz
* L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 + 0.2000000000e57 *
J__2xx * J__2zz * L__1 ^ 2 * l__2 ^ 2 * m__2 ^ 2 +
0.3365391746e38 * J__2yy * J__2zz * L__1 ^ 2 * l__2 ^ 2
* m__2 ^ 2 + 0.2000000000e57 * J__2zz ^ 2 * L__1 ^ 2 *
l__1 ^ 2 * m__1 * m__2 + 0.3365391746e38 * J__2zz ^ 2 *
l__1 ^ 2 * l__2 ^ 2 * m__1 * m__2 + 0.4000000000e57 *
J__1zz * J__2xx * J__2zz * l__2 ^ 2 * m__2 +
0.6730783492e38 * J__1zz * J__2yy * J__2zz * l__2 ^ 2 *
m__2 + 0.6730783492e38 * J__2xx * J__2yy * J__2zz *
l__2 ^ 2 * m__2 + 0.2831465401e19 * l__2 ^ 8 * m__2 ^ 4
+ 0.1000000000e57 * J__1zz ^ 2 * J__2zz ^ 2 +
0.1000000000e57 * J__2xx ^ 2 * J__2zz ^ 2 +
0.2831465401e19 * J__2yy ^ 2 * J__2zz ^ 2) *
(-0.5154810193e57 * L__1 ^ 3 * eta__g * eta__m * k__g *
k__t * l__2 ^ 3 * m__2 ^ 3 - 0.2000000003e66 * J__2zz *
L__1 * eta__g * eta__m * k__g * k__t * l__1 ^ 2 * l__2
```

```
* m__1 * m__2 - 0.2000000003e66 * J__1zz * L__1 * eta__g
* eta__m * k__g * k__t * l__2 ^ 3 * m__2 ^ 2 -
0.1999999997e66 * J__2xx * L__1 * eta__g * eta__m *
k__g * k__t * l__2 ^ 3 * m__2 ^ 2 - 0.5154810194e57 *
J__2yy * L__1 * eta__g * eta__m * k__g * k__t * l__2 ^
3 * m__2 ^ 2 - 0.2000000003e66 * J__2zz * L__1 ^ 3 *
eta__g * eta__m * k__g * k__t * l__2 * m__2 ^ 2 -
0.5154810194e57 * J__2zz * L__1 * eta__g * eta__m *
k__g * k__t * l__2 ^ 3 * m__2 ^ 2 - 0.5154810194e57 *
L__1 * eta__g * eta__m * k__g * k__t * l__2 ^ 5 * m__2
^ 3 - 0.2000000003e66 * L__1 * eta__g * eta__m * k__g *
k__t * l__1 ^ 2 * l__2 ^ 3 * m__1 * m__2 ^ 2 -
0.2000000003e66 * J__1zz * J__2zz * L__1 * eta__g *
eta__m * k__g * k__t * l__2 * m__2 - 0.1999999997e66 *
J__2xx * J__2zz * L__1 * eta__g * eta__m * k__g * k__t
* l__2 * m__2 - 0.5154810194e57 * J__2yy * J__2zz *
L__1 * eta__g * eta__m * k__g * k__t * l__2 * m__2);];
B = [0; 0; -0.3033691204e2; -0.2761910058e2;];
```

Data

```
> Matlab(data_electrical, resultname="data_e");
eta__g = 0.85e0;
eta__m = 0.87e0;
k__g = 70;
k__m = 0.76e-2;
k__t = 0.76e-2;
r__m = 0.26e1;
V__m = 10;
> Matlab(data_mechanical, resultname="data_m");
J__1zz = 0.23e-2;
m__1 = 0;
l__1 = 0.215e0;
m__2 = 0.2e0;
L__1 = 0.215e0;
J__2yy = 0.23e-2;
l__2 = 0.1675e0;
J__2xx = 0;
J__2zz = 0.23e-2;
b__1 = 0;
Vm = 0;
g = 0.981e1;
tau__2 = 0;
b__2 = 0;
```