```
> restart;
```

Equation du mouvement pendule double sphérique (méthode de Lagrange)

Position de la masse 1

```
> m1Pos:=[x[1](t)=l1*sin(theta[1](t))*cos(gamma[1](t)),y[1](t)=
  l1*sin(theta[1](t))*sin(gamma[1](t)),z[1](t)=-l1*cos(theta[1]
  (t))];
```

$$m1Pos := \left[x_1(t) = l1 \sin\left(\theta_1(t)\right) \cos\left(\gamma_1(t)\right), y_1(t) = l1 \sin\left(\theta_1(t)\right) \sin\left(\gamma_1(t)\right), z_1(t) = -l1 \cos\left(\theta_1(t)\right)\right] \quad (1.1)$$

Position de la masse 2

```
> temp1:=[x[2](t)=x[1](t)+l2*sin(theta[2](t))*cos(gamma[2](t)),
  y[2](t)=y[1](t)+l2*sin(theta[2](t))*sin(gamma[2](t)),z[2](t)=
  z[1](t)-l2*cos(theta[2](t))];
```

$$temp1 := \left[x_2(t) = x_1(t) + l2 \sin\left(\theta_2(t)\right) \cos\left(\gamma_2(t)\right), y_2(t) = y_1(t) + l2 \sin\left(\theta_2(t)\right) \sin\left(\gamma_2(t)\right), z_2(t) = z_1(t) - l2 \cos\left(\theta_2(t)\right)\right] \quad (1.2)$$

On substitu m1Pos dans m2Pos

```
> m2Pos:=subs(m1Pos,temp1);
```

$$m2Pos := \left[x_2(t) = l1 \sin\left(\theta_1(t)\right) \cos\left(\gamma_1(t)\right) + l2 \sin\left(\theta_2(t)\right) \cos\left(\gamma_2(t)\right), y_2(t) = l1 \sin\left(\theta_1(t)\right) \sin\left(\gamma_1(t)\right) + l2 \sin\left(\theta_2(t)\right) \sin\left(\gamma_2(t)\right), z_2(t) = -l1 \cos\left(\theta_1(t)\right) - l2 \cos\left(\theta_2(t)\right)\right] \quad (1.3)$$

Expression de l'energie cinétique

Expression des vitesses

```
> m1Vit:=v[1](t)=sqrt(diff(x[1](t),t)^2+diff(y[1](t),t)^2+
  diff(z[1](t),t)^2);
```

$$m1Vit := v_1(t) = \sqrt{\left(\frac{d}{dt} x_1(t)\right)^2 + \left(\frac{d}{dt} y_1(t)\right)^2 + \left(\frac{d}{dt} z_1(t)\right)^2} \quad (1.1.1)$$

```
> m2Vit:=v[2](t)=sqrt(diff(x[2](t),t)^2+diff(y[2](t),t)^2+
  diff(z[2](t),t)^2);
```

$$m2Vit := v_2(t) = \sqrt{\left(\frac{d}{dt} x_2(t)\right)^2 + \left(\frac{d}{dt} y_2(t)\right)^2 + \left(\frac{d}{dt} z_2(t)\right)^2} \quad (1.1.2)$$

On peut calculer directement les deux avec la fonction seq

```
> Vit:=[seq(v[i](t)=sqrt(diff(x[i](t),t)^2+diff(y[i](t),t)^2+
  diff(z[i](t),t)^2),i=1..2)];
```

$$Vit := \left[v_1(t) = \sqrt{\left(\frac{d}{dt} x_1(t)\right)^2 + \left(\frac{d}{dt} y_1(t)\right)^2 + \left(\frac{d}{dt} z_1(t)\right)^2}, v_2(t) = \sqrt{\left(\frac{d}{dt} x_2(t)\right)^2 + \left(\frac{d}{dt} y_2(t)\right)^2 + \left(\frac{d}{dt} z_2(t)\right)^2}\right] \quad (1.1.3)$$

On remplace l'expression de x[i](t), y[i](t) et z[i](t) dans m1Vit et m2Vit

```
> temp2:=expand(subs(m1Pos,m1Vit));
```

(1.1.4)

$$temp2 := v_1(t) \tag{1.1.4}$$

$$= \left(l1^2 \cos\left(\theta_1(t)\right)^2 \left(\frac{d}{dt}\,\theta_1(t) \right)^2 \cos\left(\gamma_1(t)\right)^2 \right.$$

$$+ l1^2 \sin\left(\theta_1(t)\right)^2 \sin\left(\gamma_1(t)\right)^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2$$

$$+ l1^2 \cos\left(\theta_1(t)\right)^2 \left(\frac{d}{dt}\,\theta_1(t) \right)^2 \sin\left(\gamma_1(t)\right)^2$$

$$\left. + l1^2 \sin\left(\theta_1(t)\right)^2 \cos\left(\gamma_1(t)\right)^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 + l1^2 \sin\left(\theta_1(t)\right)^2 \left(\frac{d}{dt}\,\theta_1(t) \right)^2 \right)^{1/2}$$

On peut simplifier les termes trigo

```
> m1VitAngle:=combine(temp2,trig);
```

$$m1VitAngle := v_1(t) \tag{1.1.5}$$

$$= \frac{1}{2} \sqrt{4\, l1^2 \left(\frac{d}{dt}\,\theta_1(t) \right)^2 + 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 - 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 \cos\left(2\,\theta_1(t)\right)}$$

```
> m2VitAngle:=combine(expand(subs(m2Pos,m2Vit)),trig);
```

$$m2VitAngle := v_2(t) \tag{1.1.6}$$

$$= \frac{1}{2} \left(4\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) - \theta_2(t)\right) \right.$$

$$- 4\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \theta_2(t)\right)$$

$$- 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 \cos\left(2\,\theta_1(t)\right) + 4\, l2^2 \left(\frac{d}{dt}\,\theta_2(t) \right)^2$$

$$- 2\, l2^2 \left(\frac{d}{dt}\,\gamma_2(t) \right)^2 \cos\left(2\,\theta_2(t)\right) + 2\, l2^2 \left(\frac{d}{dt}\,\gamma_2(t) \right)^2$$

$$+ 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t)\right)$$

$$+ 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t)\right)$$

$$+ 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t)\right)$$

$$+ 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t)\right)$$

$$- 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t)\right)$$

$$+ 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t)\right)$$

$$\left. - 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t)\right) \right)$$

$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$\left.+4\,l1^2\left(\frac{d}{dt}\theta_1(t)\right)^2+2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\right)^{1/2}$$

Expression de l'energie potentielle

```
> Ec:=1/2*m1*v[1](t)^2+1/2*m2*v[2](t)^2;
```

$$Ec := \frac{1}{2}\,m1\,v_1(t)^2+\frac{1}{2}\,m2\,v_2(t)^2 \qquad \textbf{(1.1.7)}$$

Expression complète

```
> EcAngle:=subs(m1VitAngle,m2VitAngle,Ec);
```

$$EcAngle := \frac{1}{8}\,m1\left(4\,l1^2\left(\frac{d}{dt}\theta_1(t)\right)^2+2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\right. \qquad \textbf{(1.1.8)}$$

$$\left.-2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\cos\left(2\,\theta_1(t)\right)\right)$$

$$+\frac{1}{8}\,m2\left(4\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)-\theta_2(t)\right)\right.$$

$$-4\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\theta_2(t)\right)$$

$$-2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\cos\left(2\,\theta_1(t)\right)+4\,l2^2\left(\frac{d}{dt}\theta_2(t)\right)^2$$

$$-2\,l2^2\left(\frac{d}{dt}\gamma_2(t)\right)^2\cos\left(2\,\theta_2(t)\right)+2\,l2^2\left(\frac{d}{dt}\gamma_2(t)\right)^2$$

$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+4\,l1^2\left(\frac{d}{dt}\theta_1(t)\right)^2+2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\Bigg)$$

Expression de l'energie potentielle

```
> Ep:=m1*g*z[1](t)+m2*g*z[2](t);
```

$$Ep := m1\,g\,z_1(t) + m2\,g\,z_2(t) \qquad \textbf{(1.2.1)}$$

On substitu l'expression de z[1](t) et z[2](t) dans Ep

```
> EpAngle:=subs(m1Pos,m2Pos,Ep);
```

$$EpAngle := -m1\,g\,l1\cos\left(\theta_1(t)\right) + m2\,g\left(-l1\cos\left(\theta_1(t)\right) - l2\cos\left(\theta_2(t)\right)\right) \qquad \textbf{(1.2.2)}$$

Equation de Lagrange

Expression du Lagrangien

```
> L:=EcAngle-EpAngle;
```

$$
\begin{aligned}
L := {} & \frac{1}{8}\, m1 \left(4\, l1^2 \left(\frac{d}{dt}\,\theta_1(t) \right)^2 + 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 \right. \\
& \left. - 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 \cos\left(2\,\theta_1(t) \right) \right) \\
& + \frac{1}{8}\, m2 \left(4\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) - \theta_2(t) \right) \right. \\
& - 4\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \theta_2(t) \right) \\
& - 2\, l1^2 \left(\frac{d}{dt}\,\gamma_1(t) \right)^2 \cos\left(2\,\theta_1(t) \right) + 4\, l2^2 \left(\frac{d}{dt}\,\theta_2(t) \right)^2 \\
& - 2\, l2^2 \left(\frac{d}{dt}\,\gamma_2(t) \right)^2 \cos\left(2\,\theta_2(t) \right) + 2\, l2^2 \left(\frac{d}{dt}\,\gamma_2(t) \right)^2 \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right) \\
& - 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right) \\
& - 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\theta_1(t) \right) l2 \left(\frac{d}{dt}\,\gamma_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right) \\
& - 2\, l1 \left(\frac{d}{dt}\,\gamma_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& - 2\, l1 \left(\frac{d}{dt}\,\gamma_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(-\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\gamma_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) + \theta_2(t) - \gamma_2(t) \right) \\
& + 2\, l1 \left(\frac{d}{dt}\,\gamma_1(t) \right) l2 \left(\frac{d}{dt}\,\theta_2(t) \right) \cos\left(\theta_1(t) + \gamma_1(t) - \theta_2(t) - \gamma_2(t) \right)
\end{aligned}
\tag{1.3.1}
$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$+4\,l1^2\left(\frac{d}{dt}\theta_1(t)\right)^2+2\,l1^2\left(\frac{d}{dt}\gamma_1(t)\right)^2\Big)+m1\,g\,l1\cos\left(\theta_1(t)\right)-m2\,g\,\Big($$

$$-l1\cos\left(\theta_1(t)\right)-l2\cos\left(\theta_2(t)\right)\Big)$$

On définit les variables du pendule

```
> var:=[theta[1](t),gamma[1](t)];
```

$$var := \left[\theta_1(t), \gamma_1(t)\right] \tag{1.3.2}$$

```
> temp3:=subs([seq([diff(var[i],t)=v[i],var[i]=q[i]][],i=1..2)],L);
```

$$temp3 := \frac{1}{8}\,m1\left(4\,l1^2\,v_1^2+2\,l1^2\,v_2^2-2\,l1^2\,v_2^2\cos\left(2\,q_1\right)\right) \tag{1.3.3}$$

$$+\frac{1}{8}\,m2\left(4\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(q_1-\theta_2(t)\right)-4\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(q_1\right.\right.$$

$$\left.+\theta_2(t)\right)-2\,l1^2\,v_2^2\cos\left(2\,q_1\right)+4\,l2^2\left(\frac{d}{dt}\theta_2(t)\right)^2$$

$$-2\,l2^2\left(\frac{d}{dt}\gamma_2(t)\right)^2\cos\left(2\,\theta_2(t)\right)+2\,l2^2\left(\frac{d}{dt}\gamma_2(t)\right)^2$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)-2\,l1\,v_1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(\right.$$

$$-q_1+q_2+\theta_2(t)-\gamma_2(t)\Big)+2\,l1\,v_1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(-q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\,v_1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)-2\,l1\,v_2\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(\right.$$

$$-q_1+q_2+\theta_2(t)-\gamma_2(t)\Big)-2\,l1\,v_2\,l2\left(\frac{d}{dt}\theta_2(t)\right)\cos\left(-q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$

$$+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos($$
$$-q_1+q_2+\theta_2(t)-\gamma_2(t)\Big)-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(-q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)+4\,l1^2\,v_1^2+2\,l1^2\,v_2^2\Big)$$
$$+m1\,g\,l1\cos(q_1)-m2\,g\left(-l1\cos(q_1)-l2\cos\left(\theta_2(t)\right)\right)$$

```
> part1:=[seq(diff(temp3,v[i]),i=1..2)];
```

$$part1:=\Big[m1\,l1^2\,v_1+\frac{1}{8}\,m2\left(4\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1-\theta_2(t)\right)\right. \tag{1.3.4}$$
$$-4\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+\theta_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1-q_2-\theta_2(t)\right.$$
$$\left.+\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1\right.$$
$$\left.+q_2-\theta_2(t)-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1\right.$$
$$\left.+q_2+\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$
$$+8\,l1^2\,v_1\Big),\ \frac{1}{8}\,m1\left(4\,l1^2\,v_2-4\,l1^2\,v_2\cos(2\,q_1)\right)+\frac{1}{8}\,m2\left(-4\,l1^2\,v_2\cos(2\,q_1)\right.$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1\right.$$
$$\left.-q_2+\theta_2(t)+\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1\right.$$
$$\left.-q_2-\theta_2(t)+\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(q_1\right.$$
$$\left.+q_2-\theta_2(t)-\gamma_2(t)\right)+4\,l1^2\,v_2\Big)\Big]$$

```
> part2:=[seq(-diff(temp3,q[i]),i=1..2)];
```

$$part2:=\Big[-\frac{1}{2}\,m1\,l1^2\,v_2^2\sin(2\,q_1)-\frac{1}{8}\,m2\left(-4\,l1\,v_1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(q_1-\theta_2(t)\right)\right. \tag{1.3.5}$$

$$
\begin{aligned}
&+4\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+\theta_2(t)\right)+4\,l1^2\,v_2^2\sin\left(2\,q_1\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_2\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\Big)+m1\,g\,l1\sin\left(q_1\right)\\
&+m2\,g\,l1\sin\left(q_1\right),\ -\frac{1}{8}\,m2\left(2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)\right.\\
&+2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,v_1\,l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)
\end{aligned}
$$

$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,v_1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,v_1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1-q_2-\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1-q_2+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1+q_2+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,v_2\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(q_1+q_2-\theta_2(t)-\gamma_2(t)\right)\Big)\Big]$$

```
> chgt:=[seq([v[i]=diff(var[i],t),q[i]=var[i]][],i=1..2)];
```

$$chgt := \left[v_1=\frac{d}{dt}\,\theta_1(t),\ q_1=\theta_1(t),\ v_2=\frac{d}{dt}\,\gamma_1(t),\ q_2=\gamma_1(t)\right] \tag{1.3.6}$$

```
> part1Mod:=subs(chgt,part1);
```

$$part1Mod := \left[m1\,l1^2\left(\frac{d}{dt}\,\theta_1(t)\right)+\frac{1}{8}\,m2\left(4\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)-\theta_2(t)\right)\right.\right. \tag{1.3.7}$$
$$-4\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)+\theta_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)\right.$$
$$\left.-\theta_2(t)+\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$\left.+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)+8\,l1^2\left(\frac{d}{dt}\,\theta_1(t)\right)\right),$$

$$\frac{1}{8}\,m1\left(4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)-4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)\cos\left(2\,\theta_1(t)\right)\right)+\frac{1}{8}\,m2\left(\right.$$
$$-4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)\cos\left(2\,\theta_1(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)\right.$$
$$\left.+\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)+4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)\Big)\Big]$$

```
> part2Mod:=subs(chgt,part2);
```

$$part2Mod:=\left[-\frac{1}{2}\,m1\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)^2\sin\left(2\,\theta_1(t)\right)-\frac{1}{8}\,m2\left(\right.\right. \tag{1.3.8}$$
$$-4\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\theta_2(t)\right)$$
$$+4\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\theta_2(t)\right)$$
$$+4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)^2\sin\left(2\,\theta_1(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)\right.$$
$$\left.-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)\right.$$
$$\left.+\theta_2(t)+\gamma_2(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.$$
$$\left.-\gamma_2(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$
$$-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$
$$+2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)$$

$$
\begin{aligned}
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\Bigg)\\
&+m1\,g\,l1\sin\left(\theta_1(t)\right)+m2\,g\,l1\sin\left(\theta_1(t)\right),\\
&-\frac{1}{8}\,m2\left(2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)\right.\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)-\theta_2(t)+\gamma_2(t)\right)\\
&-2\,l1\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_1(t)\right) l2\left(\frac{\mathrm{d}}{\mathrm{d}t}\,\gamma_2(t)\right)\sin\left(\theta_1(t)-\gamma_1(t)+\theta_2(t)+\gamma_2(t)\right)
\end{aligned}
$$

$$+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\Bigg]$$

```
> eom:=[seq(diff(part1Mod[i],t)+part2Mod[i]=0,i=1..2)];
```

$$eom := \Bigg[m1\,l1^2\left(\frac{d^2}{dt^2}\theta_1(t)\right)+\frac{1}{8}\,m2\left(4\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\theta_1(t)-\theta_2(t)\right)\right. \tag{1.3.9}$$

$$-4\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)-\theta_2(t)\right)\left(\frac{d}{dt}\theta_1(t)-\left(\frac{d}{dt}\theta_2(t)\right)\right)$$

$$-4\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\theta_1(t)+\theta_2(t)\right)+4\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)\right.$$

$$\left.+\theta_2(t)\right)\left(\frac{d}{dt}\theta_1(t)+\frac{d}{dt}\theta_2(t)\right)+2\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)\right.$$

$$\left.+\theta_2(t)-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\left(\right.$$

$$\left.-\left(\frac{d}{dt}\theta_1(t)\right)+\frac{d}{dt}\gamma_1(t)+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)+2\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\right.$$

$$\left.-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)\right.$$

$$\left.-\gamma_2(t)\right)\left(-\left(\frac{d}{dt}\theta_1(t)\right)+\frac{d}{dt}\gamma_1(t)-\left(\frac{d}{dt}\theta_2(t)\right)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)$$

$$+2\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)$$

$$-2\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\theta_1(t)+\frac{d}{dt}\gamma_1(t)\right.$$

$$\left.+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)+2\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)\right.$$

$$\left.-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\theta_1(t)\right.$$

$$\left.+\frac{d}{dt}\gamma_1(t)-\left(\frac{d}{dt}\theta_2(t)\right)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)-2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(-\theta_1(t)\right.$$

$$\left.+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.$$

$$\left.-\gamma_2(t)\right)\left(-\left(\frac{d}{dt}\theta_1(t)\right)+\frac{d}{dt}\gamma_1(t)+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)$$

$$+2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)$$

$$
\begin{aligned}
&-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(-\left(\frac{d}{dt}\,\theta_1(t)\right)\right.\\
&\left.+\frac{d}{dt}\,\gamma_1(t)-\left(\frac{d}{dt}\,\theta_2(t)\right)-\left(\frac{d}{dt}\,\gamma_2(t)\right)\right)-2\,l1\,l2\left(\frac{d^2}{dt^2}\,\gamma_2(t)\right)\cos\left(\theta_1(t)\right.\\
&\left.+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.\\
&\left.-\gamma_2(t)\right)\left(\frac{d}{dt}\,\theta_1(t)+\frac{d}{dt}\,\gamma_1(t)+\frac{d}{dt}\,\theta_2(t)-\left(\frac{d}{dt}\,\gamma_2(t)\right)\right)\\
&+2\,l1\,l2\left(\frac{d^2}{dt^2}\,\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\,\theta_1(t)+\frac{d}{dt}\,\gamma_1(t)\right.\\
&\left.-\left(\frac{d}{dt}\,\theta_2(t)\right)-\left(\frac{d}{dt}\,\gamma_2(t)\right)\right)+8\,l1^2\left(\frac{d^2}{dt^2}\,\theta_1(t)\right)\Bigg)\\
&-\frac{1}{2}\,m1\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)^2\sin\left(2\,\theta_1(t)\right)-\frac{1}{8}\,m2\left(\right.\\
&-4\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)-\theta_2(t)\right)\\
&+4\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\theta_2(t)\right)\\
&+4\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)^2\sin\left(2\,\theta_1(t)\right)+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)\right.\\
&\left.+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)\right.\\
&\left.-\theta_2(t)-\gamma_2(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.\\
&\left.-\gamma_2(t)\right)-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\theta_1(t)\right)l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)
\end{aligned}
$$

$$
\begin{aligned}
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\,\gamma_1(t)\right) l2\left(\frac{d}{dt}\,\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\Bigg)\\
&+m1\,g\,l1\sin\left(\theta_1(t)\right)+m2\,g\,l1\sin\left(\theta_1(t)\right)=0,\ \frac{1}{8}\,m1\left(4\,l1^2\left(\frac{d^2}{dt^2}\,\gamma_1(t)\right)\right.\\
&-4\,l1^2\left(\frac{d^2}{dt^2}\,\gamma_1(t)\right)\cos\left(2\,\theta_1(t)\right)+8\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)\sin\left(2\,\theta_1(t)\right)\left(\frac{d}{dt}\,\theta_1(t)\right)\Bigg)\\
&+\frac{1}{8}\,m2\left(-4\,l1^2\left(\frac{d^2}{dt^2}\,\gamma_1(t)\right)\cos\left(2\,\theta_1(t)\right)\right.\\
&+8\,l1^2\left(\frac{d}{dt}\,\gamma_1(t)\right)\sin\left(2\,\theta_1(t)\right)\left(\frac{d}{dt}\,\theta_1(t)\right)-2\,l1\,l2\left(\frac{d^2}{dt^2}\,\theta_2(t)\right)\cos\left(-\theta_1(t)\right.\\
&+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\Big)+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.\\
&-\gamma_2(t)\Big)\left(-\left(\frac{d}{dt}\,\theta_1(t)\right)+\frac{d}{dt}\,\gamma_1(t)+\frac{d}{dt}\,\theta_2(t)-\left(\frac{d}{dt}\,\gamma_2(t)\right)\right)\\
&-2\,l1\,l2\left(\frac{d^2}{dt^2}\,\theta_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(-\left(\frac{d}{dt}\,\theta_1(t)\right)\right.\\
&+\frac{d}{dt}\,\gamma_1(t)-\left(\frac{d}{dt}\,\theta_2(t)\right)-\left(\frac{d}{dt}\,\gamma_2(t)\right)\Big)+2\,l1\,l2\left(\frac{d^2}{dt^2}\,\theta_2(t)\right)\cos\left(\theta_1(t)\right.\\
&+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\Big)-2\,l1\,l2\left(\frac{d}{dt}\,\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.
\end{aligned}
$$

$$
\begin{aligned}
&-\gamma_2(t)\Big)\left(\frac{d}{dt}\theta_1(t)+\frac{d}{dt}\gamma_1(t)+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)\\
&+2\,l1\,l2\left(\frac{d^2}{dt^2}\theta_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\,l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\theta_1(t)+\frac{d}{dt}\gamma_1(t)\right.\\
&\left.-\left(\frac{d}{dt}\theta_2(t)\right)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)+2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)\right.\\
&\left.-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\left(-\left(\frac{d}{dt}\theta_1(t)\right)\right.\\
&\left.+\frac{d}{dt}\gamma_1(t)+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)-2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(-\theta_1(t)+\gamma_1(t)\right.\\
&\left.-\theta_2(t)-\gamma_2(t)\right)+2\,l1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(\right.\\
&\left.-\left(\frac{d}{dt}\theta_1(t)\right)+\frac{d}{dt}\gamma_1(t)-\left(\frac{d}{dt}\theta_2(t)\right)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)\\
&-2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\theta_1(t)+\frac{d}{dt}\gamma_1(t)\right.\\
&\left.+\frac{d}{dt}\theta_2(t)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)+2\,l1\,l2\left(\frac{d^2}{dt^2}\gamma_2(t)\right)\cos\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)\right.\\
&\left.-\gamma_2(t)\right)-2\,l1\,l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\left(\frac{d}{dt}\theta_1(t)\right.\\
&\left.+\frac{d}{dt}\gamma_1(t)-\left(\frac{d}{dt}\theta_2(t)\right)-\left(\frac{d}{dt}\gamma_2(t)\right)\right)+4\,l1^2\left(\frac{d^2}{dt^2}\gamma_1(t)\right)\Big)-\frac{1}{8}\,m2\,\Big(\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right)l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)
\end{aligned}
$$

$$
\begin{aligned}
&+2\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\theta_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\theta_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(-\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\\
&+2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)+\theta_2(t)-\gamma_2(t)\right)\\
&-2\,l1\left(\frac{d}{dt}\gamma_1(t)\right) l2\left(\frac{d}{dt}\gamma_2(t)\right)\sin\left(\theta_1(t)+\gamma_1(t)-\theta_2(t)-\gamma_2(t)\right)\Big)=0\Big]
\end{aligned}
$$

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