```
Clear["Global`*"]
```
清除

```
P1 = {Cos[Ω1] Cos[ω1] - Sin[Ω1] Sin[ω1] Cos[i1],
   Sin[Ω1] Cos[ω1] + Cos[Ω1] Sin[ω1] Cos[i1], Sin[ω1] Sin[i1]}
```
余弦 余弦 正弦 正弦 余弦 正弦 余弦 余弦 正弦 余弦 正弦 正弦

```
Q1 = {-Cos[Ω1] Sin[ω1] - Sin[Ω1] Cos[ω1] Cos[i1],
   -Sin[Ω1] Sin[ω1] + Cos[Ω1] Cos[ω1] Cos[i1], Cos[ω1] Sin[i1]}
```
余弦 正弦 正弦 余弦 余弦 正弦 正弦 余弦 余弦 余弦 余弦 正弦

```
{Cos[ω1] Cos[Ω1] - Cos[i1] Sin[ω1] Sin[Ω1],
 Cos[i1] Cos[Ω1] Sin[ω1] + Cos[ω1] Sin[Ω1], Sin[i1] Sin[ω1]}
```

```
{-Cos[Ω1] Sin[ω1] - Cos[i1] Cos[ω1] Sin[Ω1],
 Cos[i1] Cos[ω1] Cos[Ω1] - Sin[ω1] Sin[Ω1], Cos[ω1] Sin[i1]}
```

$$a1 = \frac{6\,678\,137}{6\,378\,140};\ e1 = 0.1;\ i1 = 45\,°;\ \Omega 1 = 45\,°;\ \omega 1 = 45\,°;\ E1 = 0;\ \mu = 1;$$

$$r1[0] = N\left[a1\,(\mathrm{Cos}[E1] - e1) * P1 + a1\sqrt{1 - e1^2}\ \mathrm{Sin}[E1] * Q1\right]$$
数… 余弦 正弦

```
{0.138001, 0.80433, 0.471166}
```

$$r1'[0] = N\left[\frac{\sqrt{\mu\, a1}}{\sqrt{r1[0][[1]]^2 + r1[0][[2]]^2 + r1[0][[3]]^2}}\left(-\mathrm{Sin}[E1]\ P1 + \sqrt{1 - e1^2}\ \mathrm{Cos}[E1]\ Q1\right)\right]$$
数值运算 正弦 余弦

```
{-0.9222, -0.158225, 0.540212}
```

$$eq1 = \left\{x1''[t] == \frac{-\mu}{\left(\sqrt{x1[t]^2 + y1[t]^2 + z1[t]^2}\right)^3}\,x1[t],\right.$$
$$y1''[t] == \frac{-\mu}{\left(\sqrt{x1[t]^2 + y1[t]^2 + z1[t]^2}\right)^3}\,y1[t],$$
$$\left.z1''[t] == \frac{-\mu}{\left(\sqrt{x1[t]^2 + y1[t]^2 + z1[t]^2}\right)^3}\,z1[t]\right\}$$

$$\left\{x1''[t] == -\frac{x1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}},\right.$$
$$\left.y1''[t] == -\frac{y1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}},\ z1''[t] == -\frac{z1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}}\right\}$$

```
eq2 = {x1[0] == r1[0][[1]], y1[0] == r1[0][[2]], z1[0] == r1[0][[3]]}
```

```
{x1[0] == 0.138001, y1[0] == 0.80433, z1[0] == 0.471166}
```

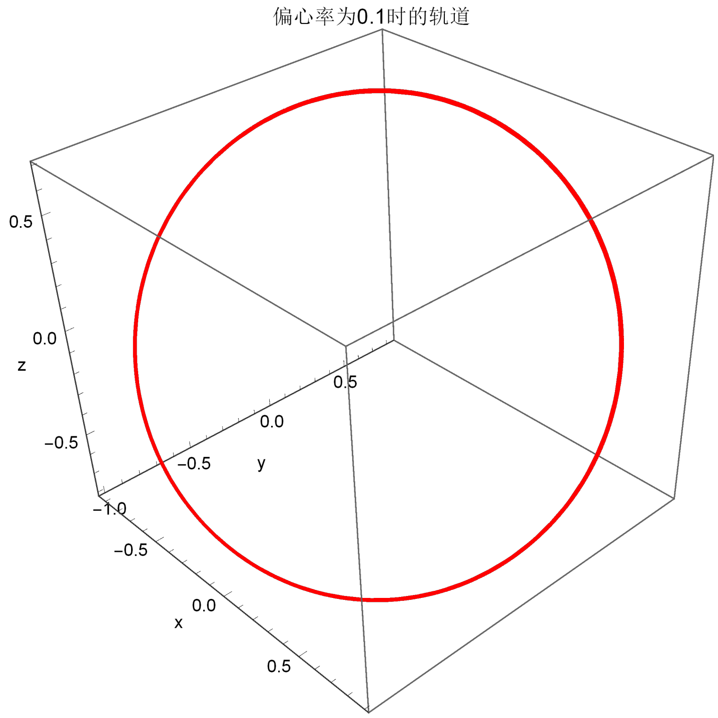
```
eq3 = {x1'[0] == r1'[0][[1]], y1'[0] == r1'[0][[2]], z1'[0] == r1'[0][[3]]}
```

```
{x1'[0] == -0.9222, y1'[0] == -0.158225, z1'[0] == 0.540212}
```

```
sol1 = NDSolve[Flatten[{eq1, eq2, eq3}], {x1[t], y1[t], z1[t], x1'[t], y1'[t], z1'[t]},
       数值…     压平
  {t, 0, 1000}, MaxSteps → 100000, Method → "ImplicitRungeKutta"]
                最多步数              方法
```

```
{{x1[t] → InterpolatingFunction[{{0., 1000.}}, <>][t],
  y1[t] → InterpolatingFunction[{{0., 1000.}}, <>][t],
  z1[t] → InterpolatingFunction[{{0., 1000.}}, <>][t],
  x1′[t] → InterpolatingFunction[{{0., 1000.}}, <>][t],
  y1′[t] → InterpolatingFunction[{{0., 1000.}}, <>][t],
  z1′[t] → InterpolatingFunction[{{0., 1000.}}, <>][t]}}
```

```
plot1 = ParametricPlot3D[Flatten[Evaluate[{x1[t], y1[t], z1[t]} /. sol1]],
        绘制三维参数图      压平    计算
  {t, 0, 1000}, AspectRatio → 1, BoxRatios → 1,
                宽高比            边界框比例
  AxesLabel → {"x", "y", "z"}, PlotLabel → "偏心率为0.1时的轨道",
  坐标轴标签                    绘图标签
  AxesEdge → {{-1, -1}, {-1, -1}, {-1, -1}}, PlotStyle → RGBColor[1, 0, 0]]
  坐标轴的边                                  绘图样式     RGB颜色
```




```
a2 = 6678137/6378140; e2 = 0.0001; i2 = 45 °; Ω2 = 45 °; ω2 = 45 °; E2 = 0; μ = 1;
```

```
P2 = {Cos[Ω2] Cos[ω2] - Sin[Ω2] Sin[ω2] Cos[i2],
      余弦     余弦      正弦     正弦     余弦
   Sin[Ω2] Cos[ω2] + Cos[Ω2] Sin[ω2] Cos[i2], Sin[ω2] Sin[i2]};
   正弦     余弦      余弦     正弦     余弦      正弦     正弦
Q2 = {-Cos[Ω2] Sin[ω2] - Sin[Ω2] Cos[ω2] Cos[i2],
       余弦     正弦      正弦     余弦     余弦
   -Sin[Ω2] Sin[ω2] + Cos[Ω2] Cos[ω2] Cos[i2], Cos[ω2] Sin[i2]};
    正弦     正弦      余弦     余弦     余弦      余弦     正弦
```

```
r2[0] = N[a2 (Cos[E2] - e2) * P2 + a2 Sqrt[1 - e2^2] Sin[E2] * Q2]
          数…  余弦                               正弦
```

{0.153319, 0.893611, 0.523465}

```
r2'[0] =
```

$$N\left[\frac{\sqrt{\mu\, a2}}{\sqrt{r2[0][[1]]^2 + r2[0][[2]]^2 + r2[0][[2]]^2}}\left(-\mathrm{Sin}[E2]\ P2 + \sqrt{1 - e2^2}\ \mathrm{Cos}[E2]\ Q2\right)\right]$$

数值运算 正弦 余弦

{-0.68608, -0.117713, 0.401897}

$$eq4 = \left\{x2''[t] == \frac{-\mu}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{\frac{3}{2}}} x2[t],\ y2''[t] == \frac{-\mu}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{\frac{3}{2}}} y2[t],\ z2''[t] == \frac{-\mu}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{\frac{3}{2}}} z2[t]\right\}$$

$$\left\{x2''[t] == -\frac{x2[t]}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{3/2}},\ y2''[t] == -\frac{y2[t]}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{3/2}},\ z2''[t] == -\frac{z2[t]}{\left(x2[t]^2 + y2[t]^2 + z2[t]^2\right)^{3/2}}\right\}$$

```
eq5 = {x2[0] == r2[0][[1]], y2[0] == r2[0][[2]], z2[0] == r2[0][[3]]}
```

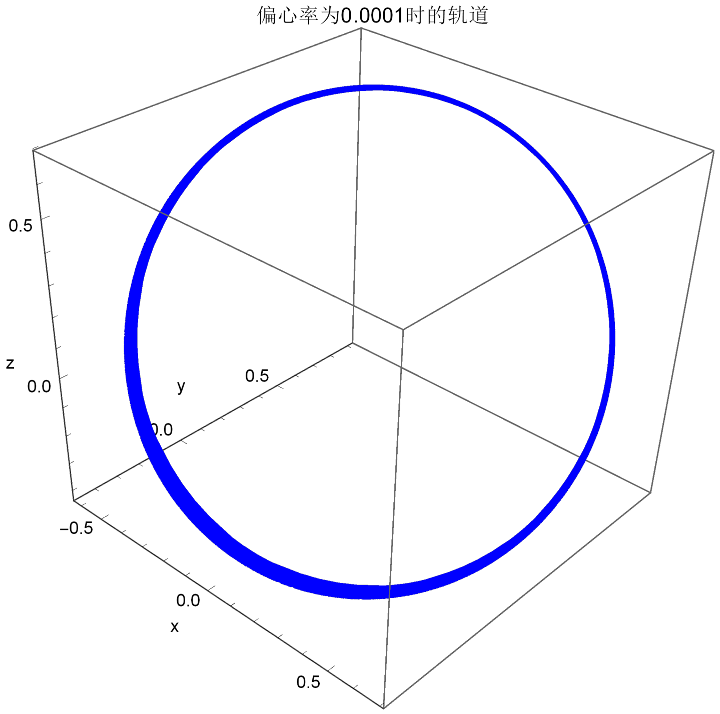
{x2[0] == 0.153319, y2[0] == 0.893611, z2[0] == 0.523465}

```
eq6 = {x2'[0] == r2'[0][[1]], y2'[0] == r2'[0][[2]], z2'[0] == r2'[0][[3]]}
```

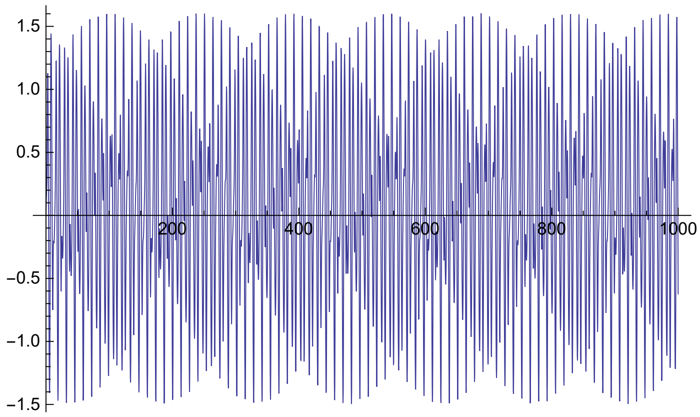
{x2′[0] == -0.68608, y2′[0] == -0.117713, z2′[0] == 0.401897}

```
sol2 = NDSolve[Flatten[{eq4, eq5, eq6}], {x2[t], y2[t], z2[t], x2'[t], y2'[t], z2'[t]},
       数值…    压平
   {t, 0, 1000}, MaxSteps → 100000, Method → "ImplicitRungeKutta"];
                 最多步数              方法
```

```
plot2 = ParametricPlot3D[Evaluate[{x2[t], y2[t], z2[t]} /. sol2],
  {t, 0, 1000}, AspectRatio → 1, BoxRatios → 1,
  AxesLabel → {"x", "y", "z"}, PlotLabel → "偏心率为0.0001时的轨道",
  AxesEdge → {{-1, -1}, {-1, -1}, {-1, -1}}, PlotStyle → RGBColor[0, 0, 1]]
```

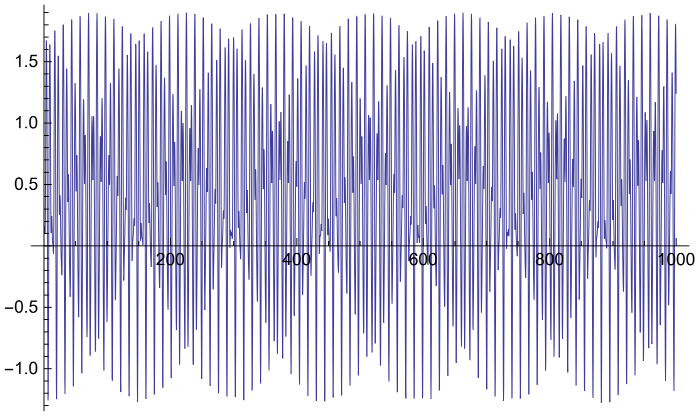



```
Plot[Evaluate[x2[t] /. sol2] - Evaluate[x1[t] /. sol1], {t, 0, 1000}]
```



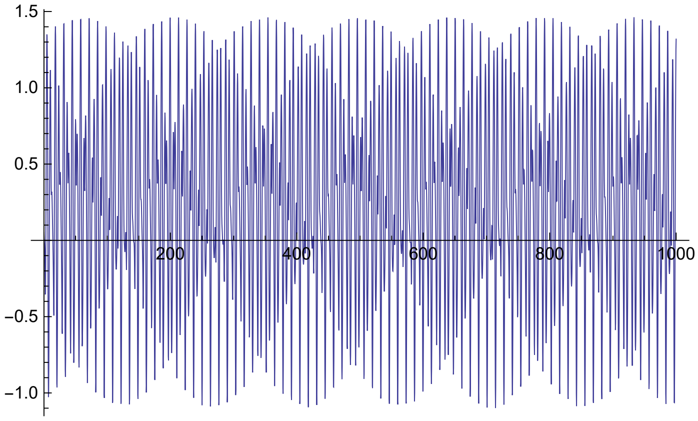
```
Plot[Evaluate[y2[t] /. sol2] - Evaluate[y1[t] /. sol1], {t, 0, 1000}]
```

绘图 计算 计算

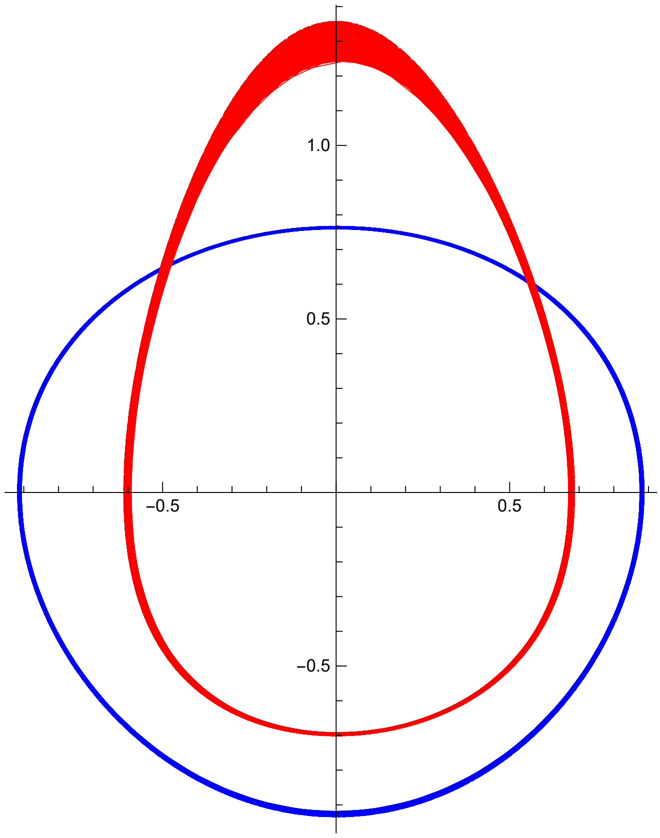



```
Plot[Evaluate[z2[t] /. sol2] - Evaluate[z1[t] /. sol1], {t, 0, 1000}]
```

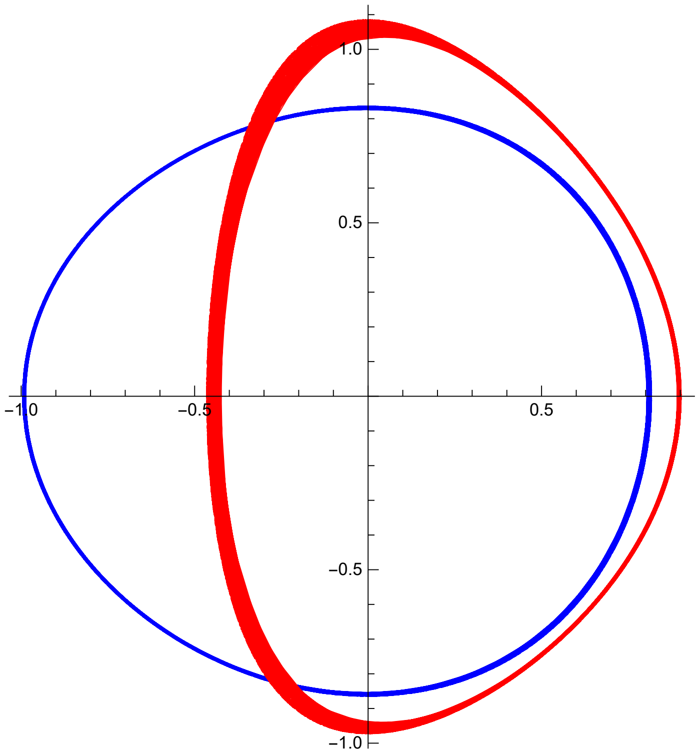
绘图 计算 计算



```
ParametricPlot[{Evaluate[{x1[t], x1'[t]} /. sol1], Evaluate[{x2[t], x2'[t]} /. sol2]},
绘制参数图              计算                                         计算
 {t, 0, 1000}, PlotStyle → {RGBColor[0, 0, 1], RGBColor[1, 0, 0]}]
                绘图样式      RGB颜色              RGB颜色
```

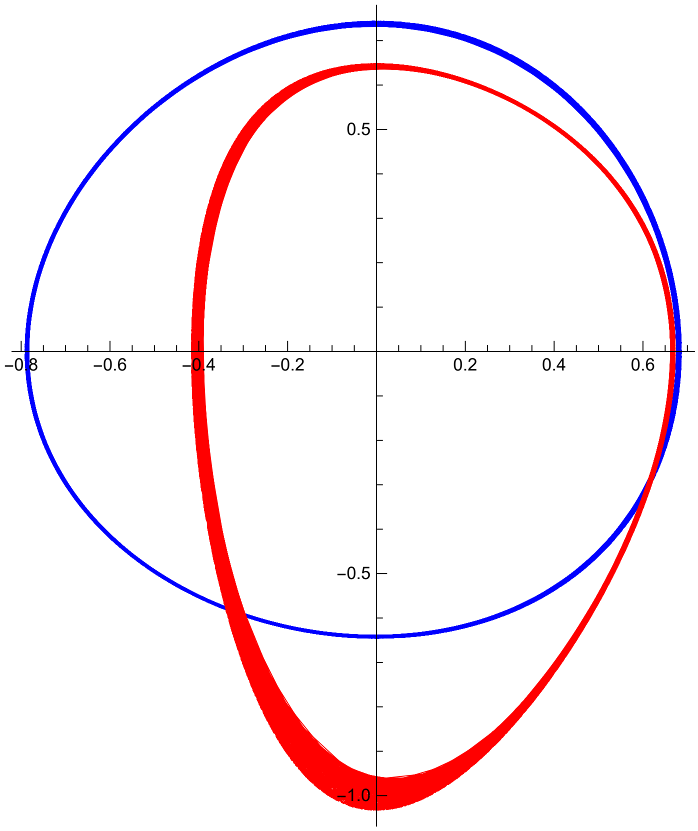


```
ParametricPlot[{Evaluate[{y1[t], y1'[t]} /. sol1], Evaluate[{y2[t], y2'[t]} /. sol2]},
绘制参数图              计算                                    计算
 {t, 0, 1000}, PlotStyle → {RGBColor[0, 0, 1], RGBColor[1, 0, 0]}]
                绘图样式      RGB颜色              RGB颜色
```



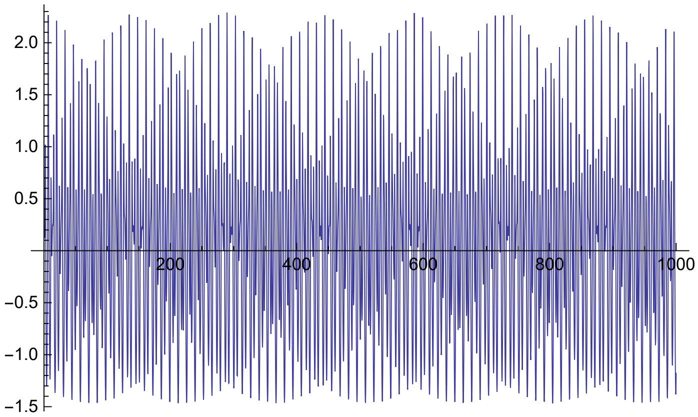
```
ParametricPlot[{Evaluate[{z1[t], z1'[t]} /. sol1], Evaluate[{z2[t], z2'[t]} /. sol2]},
 {t, 0, 1000}, PlotStyle → {RGBColor[0, 0, 1], RGBColor[1, 0, 0]}]
```

绘制参数图 计算 计算 绘图样式 RGB颜色 RGB颜色

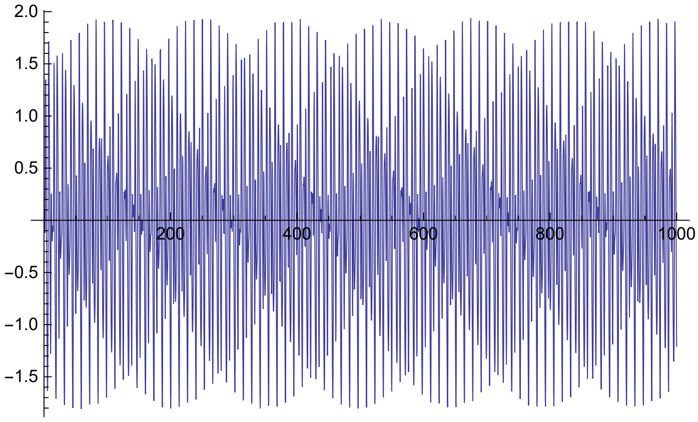



```
Plot[Evaluate[x2'[t] /. sol2] - Evaluate[x1'[t] /. sol1], {t, 0, 1000}]
```

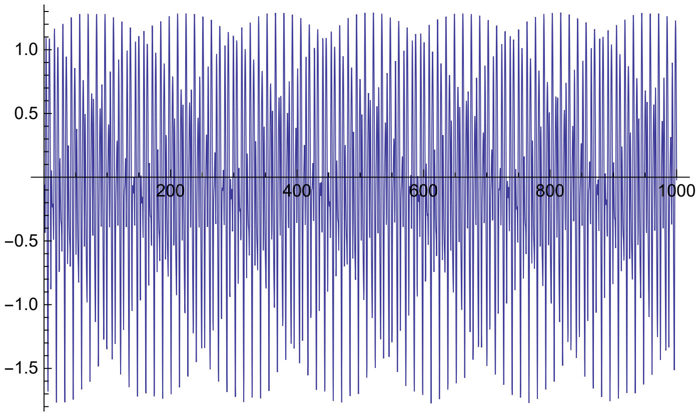
绘图 计算 计算



```
Plot[Evaluate[y2'[t] /. sol2] - Evaluate[y1'[t] /. sol1], {t, 0, 1000}]
```
绘图 计算 计算




```
Plot[Evaluate[z2'[t] /. sol2] - Evaluate[z1'[t] /. sol1], {t, 0, 1000}]
```
绘图 计算 计算




```
DSolve[Flatten[{eq1, eq2, eq3}], {x1[t], y1[t], z1[t]}, t]
```
求解⋯ 压平

$$\mathrm{DSolve}\Big[\Big\{x1''[t] == -\frac{x1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}},\; y1''[t] == -\frac{y1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}},\; z1''[t] == -\frac{z1[t]}{\left(x1[t]^2 + y1[t]^2 + z1[t]^2\right)^{3/2}},$$
$$x1[0] == 0.138001,\; y1[0] == 0.80433,\; z1[0] == 0.471166,\; x1'[0] == -0.9222,\; y1'[0] == -0.158225,\; z1'[0] == 0.540212\Big\},\; \{x1[t], y1[t], z1[t]\},\; t\Big]$$

$$\sqrt{r1[0][[1]]^2 + r1[0][[2]]^2 + r1[0][[3]]^2}$$

0.942332

```
Norm[r2[0]]
```
模

1.04693