

Вычислим моменты инерции

```
In[169]:=
Cz = m * r^2 / 2
Cxy = m * (h^2 / 12 + r^2 / 4)
```

Гироскопический момент

```
In[171]:=
Hg = Cz * ω
```

Обобщенные координаты

```
In[172]:=
s = D[β[t], t]
s1 = D[α[t], t]
s2 = D[γ[t], t]
```

Силы, действующие по осям

```
In[175]:=
fx = 0
fy = (Hg s1 - d s) Cos[β[t]]
fz = 0

In[178]:=
fxyz = {{fx}, {fy}, {fz}} // MatrixForm
```

Кинетическая энергия

```
In[179]:=
Tk = Cxy * s^2 / 2 + Cxy * s1^2 / 2 + Cz * (ω + s2)^2 / 2
```

Запись уравнений Лагранжа

```
In[180]:=
wx = Integrate [fx, α[t]]
wy = Integrate [fy, β[t]]
wz = Integrate [fz, γ[t]]

In[183]:=
qxyz = {{D[wx, α[t]]}, {D[wy, β[t]]}, {D[wz, γ[t]]}}

In[184]:=
ddTkDqdt = {{D[D[Tk, s1], t]}, {D[D[Tk, s], t]}, {D[D[Tk, s2], t]}}

In[185]:=
dTkDq = {{D[Tk, α[t]]}, {D[Tk, β[t]]}, {D[Tk, γ[t]]}}

In[186]:=
df = ddTkDqdt - dTkDq - qxyz

In[187]:=
df = ReplaceAll[df, D[s1, t] → D[q11[t], t]]
```

Представление в форме Коши

```
In[188]:=
m1 = {Solve[q11[t] - D[α[t], t] == 0, D[α[t], t]],
      Solve[Flatten[df[[1, 1]]] == 0, D[q11[t], t]]} // MatrixForm

In[189]:=
df = ReplaceAll[df, {D[β[t], t] → q21[t], β[t] → q22[t], D[β[t], {t, 2}] → D[q21[t], t]}]

In[221]:=
m2 = {{q21[t] - D[β[t], t]}, {D[q22[t], t] - D[β[t], t]}, {Flatten[df[[2, 1]]]}} // MatrixForm
```

```

In[223]:=
m2k =
  {Solve[q21[t] - D[β[t], t] == 0, D[β[t], t]], Solve[D[q22[t], t] - D[β[t], t] == 0, D[q22[t], t]],
  Solve[Flatten[df[[2, 1]]] == 0, D[q21[t], t]]} // MatrixForm

In[224]:=
df = ReplaceAll[df, {D[s2, t] → D[q32[t], t]}]

In[226]:=
m3 = {Solve[q31[t] - D[γ[t], t] == 0, D[γ[t], t]],
  Solve[Flatten[df[[3, 1]]] == 0, D[q32[t], t]]} // MatrixForm

```

Ввод упрощений

```

In[227]:=
ReplaceAll[m1, D[α[t], t] → 0]
ReplaceAll[m3, D[γ[t], t] → 0]
m2 = ReplaceAll[m2, {Cos[q22[t]] → 1, D[q21[t], t] → 0, D[α[t], t] → Ω}]

```

Решение

```

In[230]:=
resh0 = Flatten[Solve[Flatten[m2[[1, 3]]] == 0, q21[t]]]
Clear[β]
m2 = ReplaceAll[m2, resh0[[1]]]
resh = Flatten[DSolve[{m2[[1, 1]][[1]] == 0, β[0] == 0}, β[t], t]]

```

Подстановка

```

In[234]:=
resh = ReplaceAll[resh, {m → dr^2 Pi / 4 * h * ro, r^2 → dr^2 / 4}]
resh = ReplaceAll[resh, {dr → 2, h → 1, d → 10000, ω → 20000 2 Pi / 60, ro → 7.8}]
resh = ReplaceAll[resh, Ω → 0.2]

```

```

In[204]:=
Построение графика

```

```

In[237]:=
tn = 0
tk = 5

```

```

In[239]:=
Plot[resh[[1, 2]], {t, tn, tk}]

```

```

In[240]:=
ReplaceAll[resh, {t → tk}]

```