## Messwerte für Geometrie

In[912]:=
```
l1 = 0.097 + 0.043 + 0.142 + 0.116 + 0.028 + 0.0735
sl1 = 0.0005 + 0.0005 + 0.002 + 0.002 + 0.0005 + 0.0005
l2 = 0.083 + 0.043 + 0.142
sl2 = 0.0005 + 0.0005 + 0.002
l3 := 0.043
sl3 := 0.005
l4 := 0.142
sl4 := 0.002
l5 := 0.116
sl5 := 0.002
l6 := 0.028
sl6 := 0.0005
l7 = l5 + l6 + 0.0735
sl7 = sl5 + sl6 + 0.0005
```

Out[912]= 0.4995

Out[913]= 0.006

Out[914]= 0.268

Out[915]= 0.003

Out[924]= 0.2175

Out[925]= 0.003

In[926]:=
```
r1 := 0.03
sr1 := 0.00025
r2 := 0.1225
sr2 := 0.002
r3 := 0.004725
sr3 := 0.0005
```

In[932]:=
```
m1 := 1.324
sm1 := 0.002
m2 := 0.1532 * l1 / 0.248
sm2 := 0.002
m3 := 0.936
sm3 := 0.0005
m4 := 0.100
sm4 := 0.0005
```

## Messwerte für Pendelschwingung

In[940]:=
```
TP1 := (18.74 + 18.81) * 0.5
TP2 := (19 + 18.51) * 0.5
TP3 := (18.76 + 18.74) * 0.5
sTP := 0.5
```

In[944]:=
```
g := 9.81
```

## Messwerte für die Präzession

In[945]:=
```
mP1 := 0.060
mP2 := 0.080
mP3 := 0.100
smP := 0.0005
mu1 := 14.1003
smu1 := 0.3976
mu2 := 20.5209
smu2 := 1.617
mu3 := 26.1883
smu3 := 0.7799
```

## Messwerte für die Nutation

In[955]:=
```
dNut := 0.06
sdNut := 0.06
K2 := 0.155104
sK2 := 0.002912
```

In[959]:= $$\text{TPendel} = \frac{\text{TP1} + \text{TP2} + \text{TP3}}{30}$$

Out[959]= 1.876

In[960]:= $$\text{sTPendel} = \frac{\text{sTP}}{10 * \text{Sqrt}[3]}$$

Out[960]= 0.0288675

In[961]:= $$\text{JFT} = \frac{1}{2}\, \text{m1} * \text{r2}\,\hat{}\,2$$

Out[961]= 0.00993414

In[962]:= $$\text{sJFT} = \sqrt{(\text{m1 r2 sr2})^2 + \left(\frac{\text{r2}^2\ \text{sm1}}{2}\right)^2}$$

Out[962]= 0.000324727

In[963]:= $$\text{JScheibe} = \text{m1}\left(\left(\text{l5} + \frac{\text{l6}}{2}\right)^2 + \frac{\text{l6}^2}{12} + \frac{\text{r2}^2}{4}\right)$$

Out[963]= 0.0274292

In[964]:= $$\text{sJScheibe} = \sqrt{\left(\left(\text{sm1}\left(\left(\text{l5} + \frac{\text{l6}}{2}\right)^2 + \frac{\text{l6}^2}{12} + \frac{\text{r2}^2}{4}\right)\right)^2 + \left(2\ \text{m1 sl5}\left(\text{l5} + \frac{\text{l6}}{2}\right)\right)^2 + \left(\text{m1 sl6}\left(\text{l5} + \frac{2\ \text{l6}}{3}\right)\right)^2 + \left(\frac{\text{m1 r2 sr2}}{2}\right)^2\right)}$$

Out[964]= 0.000714125

In[965]:= $$\text{JStange} = \text{m2}\left(\frac{\text{l1}^2}{12} + \left(\frac{\text{l1}}{2} - \text{l7}\right)^2 + \frac{\text{r3}^2}{4}\right)$$

Out[965]= 0.00673817

In[966]:= $$\text{sJStange} = \sqrt{\left(\left(\text{sm2}\left(\frac{\text{l1}^2}{12} + \left(\frac{\text{l1}}{2} - \text{l7}\right)^2 + \frac{\text{r3}^2}{4}\right)\right)^2 + \left(\text{m2 sl1}\left(\frac{2\ \text{l1}}{3} - \text{l7}\right)\right)^2 + \left(2\ \text{m2 sl7}\left(\frac{\text{l1}}{2} - \text{l7}\right)\right)^2 + \left(\frac{\text{m2 r3 sr3}}{2}\right)^2\right)}$$

Out[966]= 0.000226268

In[967]:= $$\text{JGegengewicht} = \text{m3}\left(\frac{\text{l3}^2}{12} + \left(\frac{\text{l3}}{2} + \text{l4}\right)^2 + \frac{\text{r1}^2}{4}\right)$$

Out[967]= 0.0253762

In[968]:= $$\text{sJGegengewicht} = \sqrt{\left(\left(\text{sm3}\left(\left(\text{l4} + \frac{\text{l3}}{2}\right)^2 + \frac{\text{l3}^2}{12} + \frac{\text{r1}^2}{4}\right)\right)^2 + \left(2\ \text{m3 sl4}\left(\text{l4} + \frac{\text{l3}}{2}\right)\right)^2 + \left(\text{m3 sl3}\left(\text{l4} + \frac{2\ \text{l3}}{3}\right)\right)^2 + \left(\frac{\text{m3 r1 sr1}}{2}\right)^2\right)}$$

Out[968]= 0.00100641

In[969]:= $$\text{JPerp} = \text{JScheibe} + \text{JStange} + \text{JGegengewicht}$$

Out[969]= 0.0595436

In[970]:= $sJPerp = \sqrt{sJGegengewicht^2 + sJScheibe^2 + sJStange^2}$

Out[970]= 0.00125461

# Pendelschwingung

Das Anschraubgewicht hat eine Länge von 3.0 cm.

In[971]:= $JFP = \frac{g\ m4\ (r2 + 0.015)\ TPendel^2}{4\ \pi^2} - m4\ (r2 + 0.015)^2$

Out[971]= 0.0101342

In[972]:= $sJFP = \sqrt{\left(\left(\frac{g\ m4\ sr2\ TPendel^2}{4\ \pi^2} - 2\ m4\ r2\ sr2\right)^2 + \left(\frac{1}{2\ \pi^2}\ g\ m4\ r2\ sTPendel\ TPendel\right)^2 + \left(\frac{g\ r2\ sm4\ TPendel^2}{4\ \pi^2} - r2^2\ sm4\right)^2\right)}$

Out[972]= 0.000355915

# Präzession

In[973]:= $JFPr1 = \frac{g * mP1 * l2}{mu1}$

Out[973]= 0.0111873

In[974]:= $sJFPR1 = \sqrt{\left(\left(\frac{g\ l2\ mP1\ smu1}{mu1^2}\right)^2 + \left(\frac{g\ l2\ smP}{mu1}\right)^2 + \left(\frac{g\ mP1\ sl2}{mu1}\right)^2\right)}$

Out[974]= 0.000351979

In[975]:= $JFPr2 = \frac{g * mP2 * l2}{mu2}$

Out[975]= 0.0102494

In[976]:= $sJFPR2 = \sqrt{\left(\left(\frac{g\ l2\ mP2\ smu2}{mu2^2}\right)^2 + \left(\frac{g\ l2\ smP}{mu2}\right)^2 + \left(\frac{g\ mP2\ sl2}{mu2}\right)^2\right)}$

Out[976]= 0.000818247

In[977]:= $JFPr3 = \frac{g * mP3 * l2}{mu3}$

Out[977]= 0.0100391

In[978]:= $sJFPR3 = \sqrt{\left(\frac{g\ l2\ mP3\ smu3}{mu3^2}\right)^2 + \left(\frac{g\ l2\ smP}{mu3}\right)^2 + \left(\frac{g\ mP3\ sl2}{mu3}\right)^2}$

Out[978]= 0.000323314

# Trägheitsmoment

In[979]:= $JF = \left(\frac{JFP}{sJFP^2} + \frac{JFPr1}{sJFPR1^2} + \frac{JFPr2}{sJFPR2^2} + \frac{JFPr3}{sJFPR3^2} + \frac{JFT}{sJFT^2}\right) \Big/ \left(\frac{1}{sJFP^2} + \frac{1}{sJFPR1^2} + \frac{1}{sJFPR2^2} + \frac{1}{sJFPR3^2} + \frac{1}{sJFT^2}\right)$

Out[979]= 0.0102949

In[980]:= $$sJF = \sqrt{\frac{1}{\frac{1}{sJFP^2} + \frac{1}{sJFPR1^2} + \frac{1}{sJFPR2^2} + \frac{1}{sJFPR3^2} + \frac{1}{sJFT^2}}}$$

Out[980]= 0.0001655

# Nutation

In[981]:= $$Alpha = ArcSin\left[\frac{dNut}{2 * 17}\right]$$

Out[981]= 0.138372

In[982]:= $$Alpha / (2\,\pi) * 360$$

Out[982]= 7.92814

In[983]:= $$sAlpha = \sqrt{\left(\frac{dNut * sl7}{2\sqrt{1 - \frac{dNut^2}{4\,17^2}}\;17^2}\right)^2 + \left(\frac{sdNut}{2\sqrt{1 - \frac{dNut^2}{4\,17^2}}\;17}\right)^2}$$

Out[983]= 0.139275

In[984]:= $$sAlpha / (2\,\pi) * 360$$

Out[984]= 7.97989

In[985]:= $$K1 = JFT / JPerp$$

Out[985]= 0.166838

In[986]:= $$K1 = \frac{JFT}{JPerp\,Cos[Alpha]}$$

Out[986]= 0.168448

In[987]:= $$sK1 = \frac{1}{JPerp\,Cos[Alpha]}\sqrt{\left(\left(\frac{JFT\,sJPerp}{JPerp}\right)^2 + \left(\frac{JFT\,Sin[Alpha] * sAlpha}{Cos[Alpha]}\right)^2 + (sJFT)^2\right)}$$

Out[987]= 0.00732055

Diese Werte kommen aus gnuplot nutation.plot!

In[988]:= $$K2$$

Out[988]= 0.155104

In[989]:= $$\mathbf{0.155104}$$

Out[989]= 0.155104

In[990]:= $$sK2$$

Out[990]= 0.002912

Relative Abweichungen:

In[997]:= $$(-1 + (K1 / K2)) * 100$$

Out[997]= 8.60341

In[992]:= $$K1 - sK1$$

Out[992]= 0.161128

In[993]:= **K1 + sK1**

Out[993]= 0.175769

In[998]:= **(-1 + JFPr1 / JF) * 100**

Out[998]= 8.66911

In[999]:= **JFPr1**

Out[999]= 0.0111873

In[1000]:= **JF**

Out[1000]= 0.0102949

In[1001]:= **JF / JFPr1**

Out[1001]= 0.920225