# 241/341 Luftstromeigenschaften von RLC-Glidern

In[157]:=
```
Needs["ErrorBarPlots`"]
```

## Aufgabe 3

### Auswertung

Zunächst übernehmen wir die Daten aus dem Heft um daraus das entsprechende Diagramm zur Phase zu generieren. Wir verzichten auf übernahme der gesamten Daten, sondern tragen nur Frequenz und Phase ein. {f,$\phi$,$\Delta\phi$}

In[158]:=
```
data3 Hochpass =
 {{1, -18},
  {2, -32},
  {3, -44},
  {4, -51},
  {5, -58},
  {6, -62},
  {7, -65},
  {8, -69},
  {9, -70},
  {10, -72}}
```

Out[158]=
```
{{1, -18}, {2, -32}, {3, -44}, {4, -51},
 {5, -58}, {6, -62}, {7, -65}, {8, -69}, {9, -70}, {10, -72}}
```

In[159]:=
```
Δdata3 Hochpass = {0.4, 1, 2, 2, 2, 3, 3, 3, 3, 4}
```

Out[159]=
```
{0.4, 1, 2, 2, 2, 3, 3, 3, 3, 4}
```

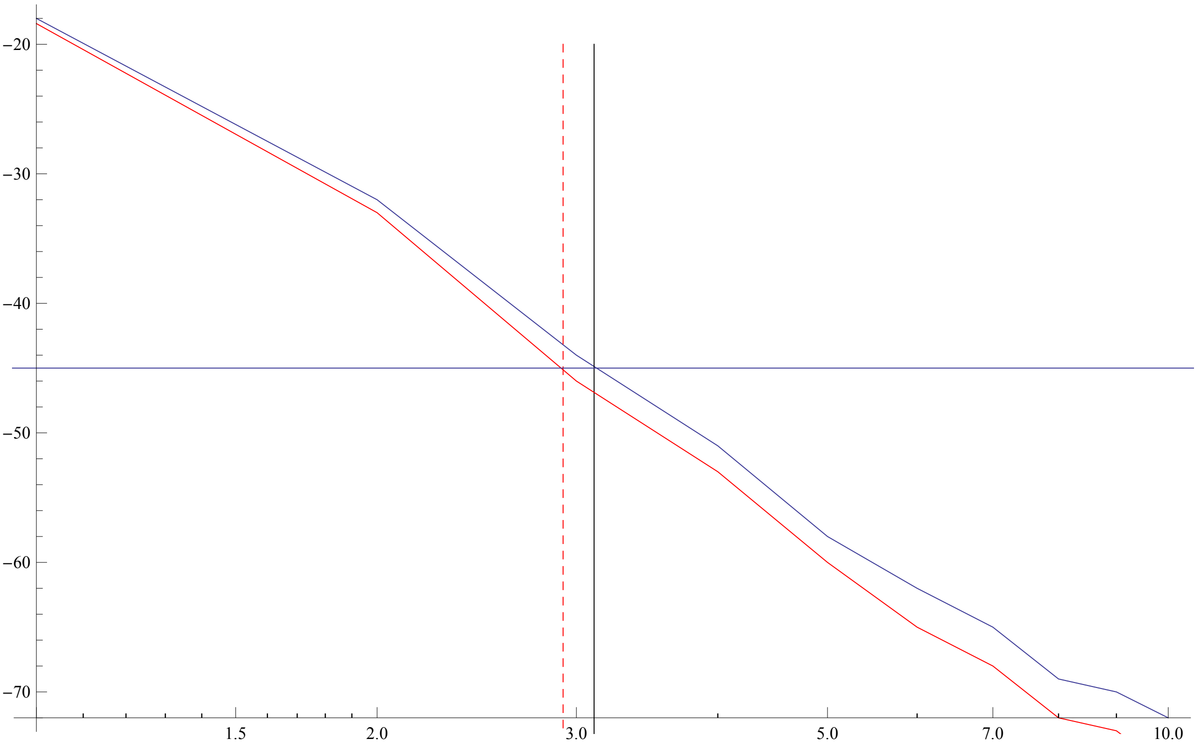
In[160]:=
```
data3 Tiefpass =
 {{1, 71},
  {2, 55},
  {3, 45},
  {4, 37},
  {5, 31},
  {6, 27},
  {7, 24},
  {8, 22},
  {9, 18},
  {10, 18}}
```

Out[160]=
```
{{1, 71}, {2, 55}, {3, 45}, {4, 37},
 {5, 31}, {6, 27}, {7, 24}, {8, 22}, {9, 18}, {10, 18}}
```

In[161]:=
```
Δdata3 Tiefpass = {1, 1, 2, 2, 2, 2, 1, 1, 2, 2}
```
Out[161]=
```
{1, 1, 2, 2, 2, 2, 1, 1, 2, 2}
```

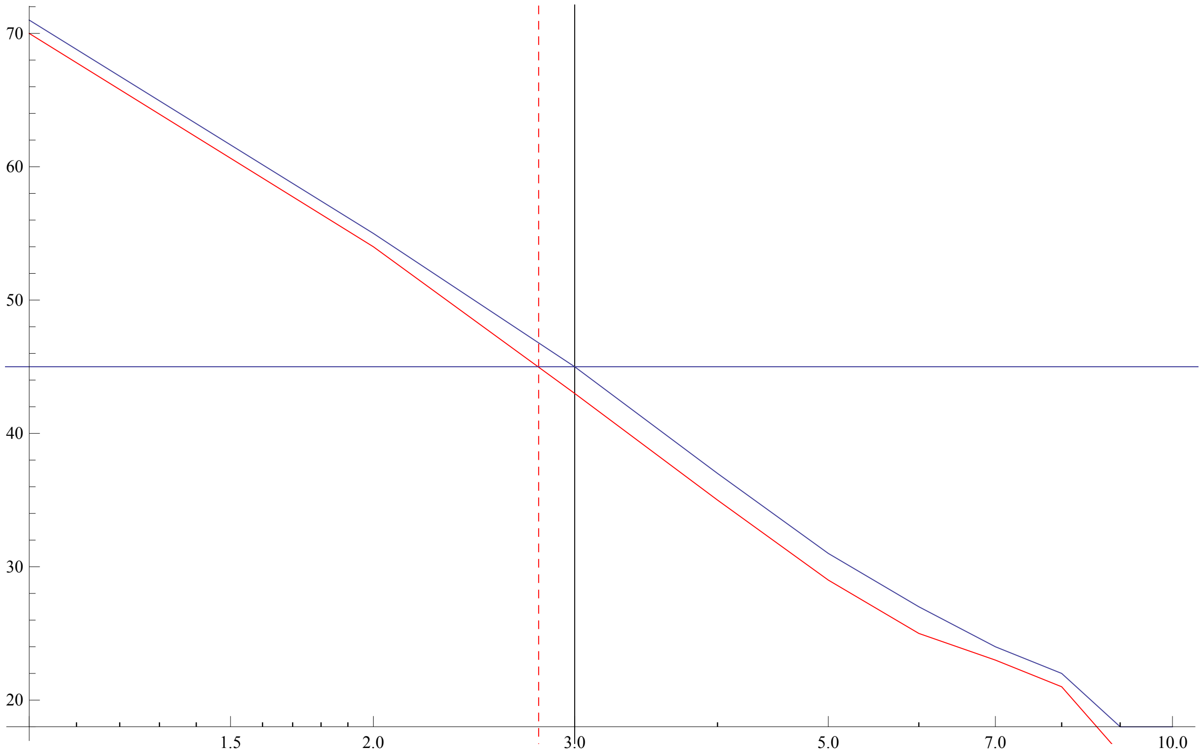
Nun tragen wir diese Daten in einem logarithmischen Plot auf.

In[162]:=
```
JetPlot1 = ListLogLinearPlot[data3 Hochpass, Joined → True];
```
In[163]:=
```
ΔJetPlot1 = ListLogLinearPlot[
   Transpose[{data3 Hochpass[[All, 1]], data3 Hochpass[[All, 2]] - Δdata3 Hochpass}],
   Joined → True, PlotStyle → Red];
```
In[164]:=
```
JetPlot2 = ListLogLinearPlot[data3 Tiefpass, Joined → True];
```
In[165]:=
```
ΔJetPlot2 = ListLogLinearPlot[
   Transpose[{data3 Tiefpass[[All, 1]], data3 Tiefpass[[All, 2]] - Δdata3 Tiefpass}],
   Joined → True, PlotStyle → Red];
```
In[166]:=
```
Show[JetPlot1,
 Graphics[{Red, Dashed, Line[{{2.92 // Log, -20}, {2.92 // Log, -80}}]}],
 Graphics[{Black, Line[{{3.11 // Log, -20}, {3.11 // Log, -80}}]}],
 ΔJetPlot1, Plot[-45, {x, -1, 10}], ImageSize → Full]
```
Out[166]=



In[167]:=
```
Show[JetPlot2,
 Graphics[{Red, Dashed, Line[{{2.79 // Log, 0}, {2.79 // Log, 80}}]}],
 Graphics[{Black, Line[{{3 // Log, 0}, {3 // Log, 80}}]}],
 ΔJetPlot2, Plot[+45, {x, -1, 10}], ImageSize → Full]
```

Out[167]=




# Aufgabe 4 - Frequenzgang eines Serienschwingkreises

Wir berechnen die Induktivität mit der Formel:

In[168]:= $L_F[C\_, \omega\_] := \frac{1}{4 * \pi\verb|^|2 * \omega\verb|^|2 * C}$

In[169]:= $\Delta L_F[C\_, \omega\_, \Delta\omega\_] := \text{Sqrt}\left[\left(\frac{\Delta\omega}{4 * \pi\verb|^|2 * \omega\verb|^|3 * C}\right)\verb|^|2\right]$

In[170]:= $\omega_R = \text{Quantity}\left[\frac{4.06 + 3.89 + 3.87}{3}, \text{"Kilohertz"}\right]$

Out[170]= 3.94 kHz

In[171]:= $\Delta\omega_R =$

$\text{Quantity}\left[\text{Sqrt}\left[\frac{(4.06 - 3.94)\verb|^|2 + (3.89 - 3.94)\verb|^|2 + (3.87 - 3.94)\verb|^|2}{2}\right], \text{"Kilohertz"}\right]$

Out[171]= 0.104403 kHz

In[172]:= `Cr = Quantity[47, "Nanofarads"]`

Out[172]= 47 nF

In[173]:= 
```
L₁ = L_F[Cr, ω_R] // UnitConvert[#, "Henries"] & // N
```
Out[173]= 0.0347176 H

In[174]:=
```
ΔL₁ = ΔL_F[Cr, ω_R, Δω_R] // UnitConvert[#, "Henries"] & // N
```
Out[174]= 0.000919956 H

In[175]:=
```
L₁ ± ΔL₁
```
Out[175]= 0.0347176 H ± 0.000919956 H

Nun berechnen wir den Gesamtwiderstand $R + R_V$.

In[176]:=
```
R_G[Δf_, Λ_] := 2 * π * Δf * Λ
```
In[177]:=
```
ΔR_G[Δf_, ΔΔf_, Λ_, ΔΛ_] := Sqrt[(2 * π * Λ * ΔΔf) ^2 + (2 * π * Δf * ΔΛ) ^2]
```
In[178]:=
```
R_G,1000Ω = R_G[Quantity[5.43, "Kilohertz"], L₁] // UnitConvert[#, "Ohms"] &
```
Out[178]= 1184.49 Ω

In[179]:=
```
ΔR_G,1000Ω = ΔR_G[Quantity[5.43, "Kilohertz"], Quantity[0.03, "Kilohertz"], L₁, ΔL₁] //
  UnitConvert[#, "Ohms"] &
```
Out[179]= 32.0617 Ω

In[180]:=
```
R_G,220Ω = R_G[Quantity[1.33, "Kilohertz"], L₁] // UnitConvert[#, "Ohms"] &
```
Out[180]= 290.123 Ω

In[181]:=
```
ΔR_G,220Ω = ΔR_G[Quantity[1.33, "Kilohertz"], Quantity[0.03, "Kilohertz"], L₁, ΔL₁] //
  UnitConvert[#, "Ohms"] &
```
Out[181]= 10.0959 Ω

In[182]:=
```
R_G,47Ω = R_G[Quantity[0.68, "Kilohertz"], L₁] // UnitConvert[#, "Ohms"] &
```
Out[182]= 148.333 Ω

In[183]:=
```
ΔR_G,47Ω = ΔR_G[Quantity[0.68, "Kilohertz"], Quantity[0.03, "Kilohertz"], L₁, ΔL₁] //
  UnitConvert[#, "Ohms"] &
```
Out[183]= 7.6338 Ω

Nun berechnen wir die Verlustwiderstände aus $U_A$ und $U_E$.

In[184]:=
$$R_V[R\_, UE\_, UA\_] := \frac{UE * R}{UA} - R$$

In[185]:=
$$\Delta R_V[R\_, UE\_, \Delta UE\_, UA\_, \Delta UA\_] := Sqrt\left[\left(R * \frac{\Delta UE}{UA}\right)^2 + \left(UE * R * \frac{\Delta UA}{UA^2}\right)^2\right]$$

In[186]:=
```
R_V,1000Ω =
 R_V[Quantity[1000, "Ohms"], Quantity[0.97, "Volts"], Quantity[0.93, "Volts"]]
```
Out[186]= 43.0108 Ω

In[187]:=
```
ΔR_V,1000Ω = ΔR_V[Quantity[1000, "Ohms"], Quantity[0.97, "Volts"],
  Quantity[0.01, "Volts"], Quantity[0.93, "Volts"], Quantity[0.01, "Volts"]]
```
Out[187]= 15.5371 Ω

```
In[188]:= Rv,220 Ω =
  Rv[Quantity[220, "Ohms"], Quantity[0.98, "Volts"], Quantity[0.76, "Volts"]]
Out[188]= 63.6842 Ω

In[189]:= ΔRv,1000 Ω = ΔRv[Quantity[220, "Ohms"], Quantity[0.98, "Volts"],
   Quantity[0.01, "Volts"], Quantity[0.76, "Volts"], Quantity[0.01, "Volts"]]
Out[189]= 4.72361 Ω

In[190]:= Rv,1000 Ω =
  Rv[Quantity[47, "Ohms"], Quantity[0.98, "Volts"], Quantity[0.36, "Volts"]]
Out[190]= 80.9444 Ω

In[191]:= ΔRv,1000 Ω = ΔRv[Quantity[47, "Ohms"], Quantity[0.98, "Volts"],
   Quantity[0.01, "Volts"], Quantity[0.36, "Volts"], Quantity[0.01, "Volts"]]
Out[191]= 3.78622 Ω
```

# 5 Bestimmung der Dämpfungskonstanten eines freien, gedämpften Schwingkreises

Zunächst berechnen wir das logarithmische Dekrement. Wir mitteln über alle Nachbarn.

```
In[192]:= Λ[B_, C_] := Log[B/C]

In[193]:= Λ12 = Λ[Quantity[2.25, "Volts"], Quantity[1.42, "Volts"]]
Out[193]= 0.460273

In[194]:= Λ23  = Λ[Quantity[1.42, "Volts"], Quantity[0.91, "Volts"]]
Out[194]= 0.444968

In[195]:= Λ34 = Λ[Quantity[0.91, "Volts"], Quantity[0.60, "Volts"]]
Out[195]= 0.416515

In[196]:= Λ45 = Λ[Quantity[0.60, "Volts"], Quantity[0.39, "Volts"]]
Out[196]= 0.430783

In[197]:= ΛM = (Λ12 + Λ23 + Λ34 + Λ45)/4
Out[197]= 0.438135

In[198]:= ΔΛM = Sqrt[1/3 * ((Λ12 - ΛM)^2 + (Λ23 - ΛM)^2 + (Λ34 - ΛM)^2 + (Λ45 - ΛM)^2)]
Out[198]= 0.0187818
```

Für die Berechnung der Dämpfungskonstante ist es nötig auch die Periode zu messen. Wir mitteln über alle unsere Werte und multiplizieren sie mit 2.

```
In[199]:= T = 2 * {128, 126, 127, 128, 124, 126}
Out[199]= {256, 252, 254, 256, 248, 252}
```

In[200]:= `TM = Median[T] // N`

Out[200]= 253.

In[201]:= `ΔTM = StandardDeviation[T] // N`

Out[201]= 3.03315

Jetzt ergibt sich die Dämpfungskonstante

In[202]:= $\delta$ = Quantity$\left[\frac{\Lambda M}{TM}, \frac{1}{\text{"Microseconds"}}\right]$

Out[202]= 0.00173176 reciprocal microseconds

In[203]:= $\Delta\delta$ = Quantity$\left[\text{Sqrt}\left[\left(\frac{\Delta\Lambda M}{TM}\right)\text{^}2 + \left(\frac{\Delta TM * \Lambda M}{TM\text{^}2}\right)\text{^}2\right], \frac{1}{\text{"Microseconds"}}\right]$

Out[203]= 0.000077085 reciprocal microseconds

Nun berechnen wir aus $L_1$ und $\delta$ den Gesamtwiderstand.

In[204]:= $R_{GG}$ = $\delta$ * 2 * $L_1$ // UnitConvert[#, "Ohms"] &

Out[204]= 120.245 Ω

In[205]:= $\Delta R_{GG}$ = Sqrt[($\Delta L_1$ * 2 * $\delta$)^2 + ($L_1$ * 2 * $\Delta\delta$)^2] // UnitConvert[#, "Ohms"] &

Out[205]= 6.22902 Ω

Wir berechnen nun mit $L_1$ die Resonanzfrequenz.

In[206]:= Resonanz = $\frac{1}{2 * \pi * \text{Sqrt}[L_1 * Cr]}$ // UnitConvert[#, "Hertz"] &

Out[206]= 3940. Hz

In[209]:= ΔResonanz = Sqrt$\left[\left(\frac{\Delta L_1 * Cr}{2 * (L_1 * Cr)\text{^}(3/2)}\right)\text{^}2\right]$ // UnitConvert[#, "Hertz"] &

Out[209]= 327.992 Hz