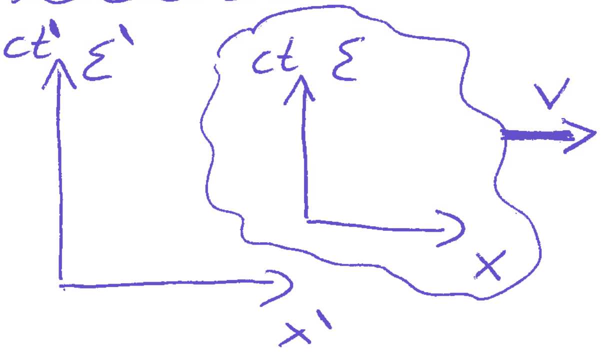
Bild - 001



Σ bewegt sich mit Geschwindigkeit v in Σ'

Bild - 002

Lichtkegel

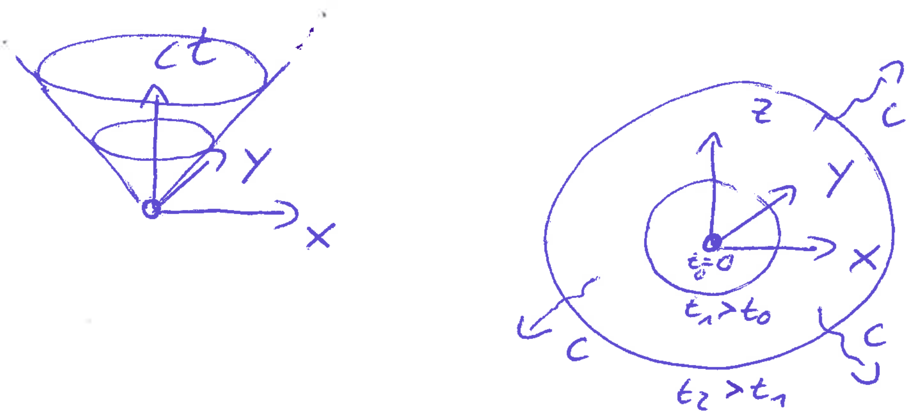


Bild - 003

$$v/c = \tanh(\phi)$$

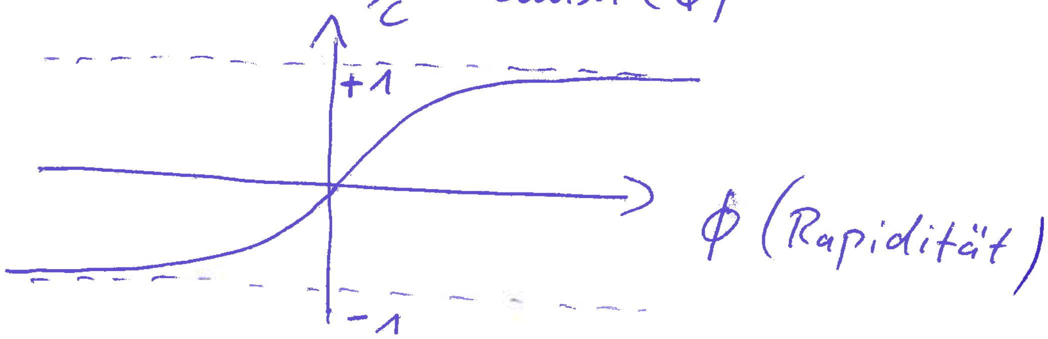


Bild - 004

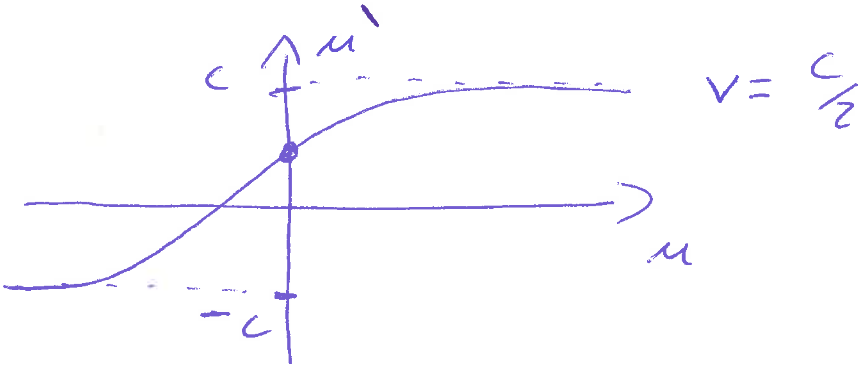


Bild - 005

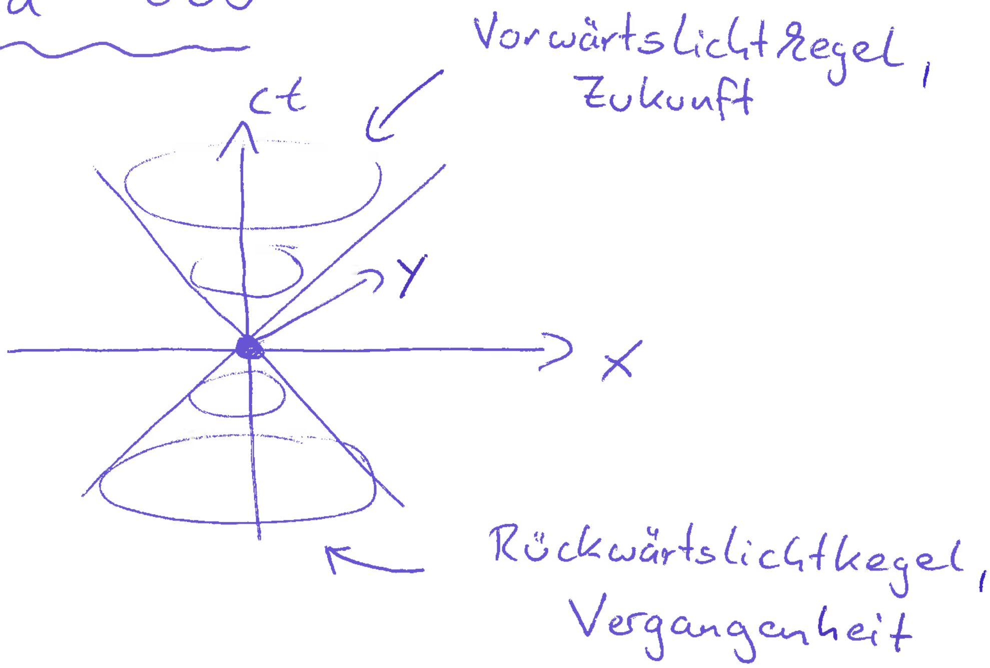


Bild - 006

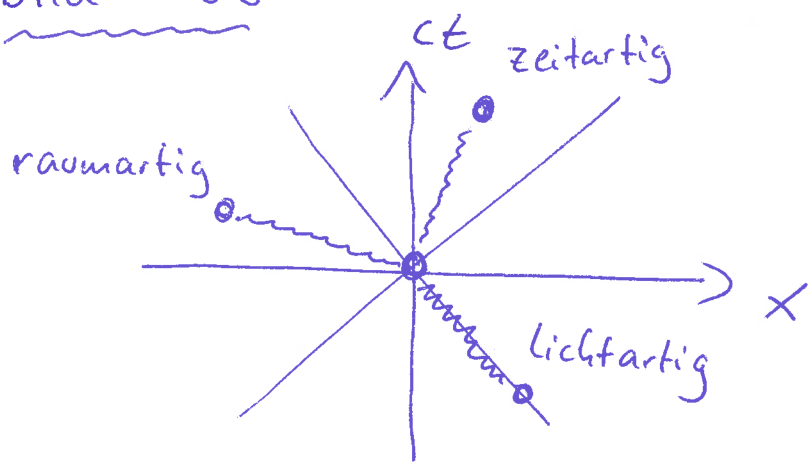
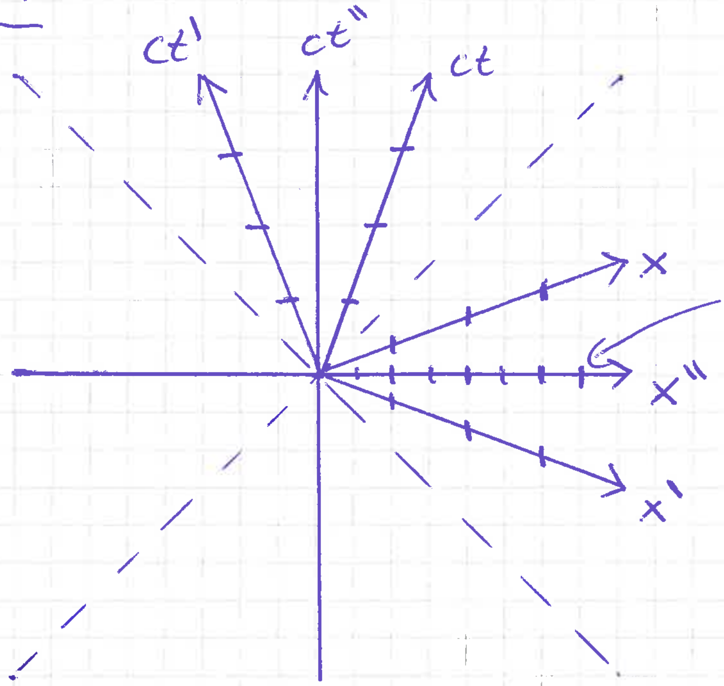
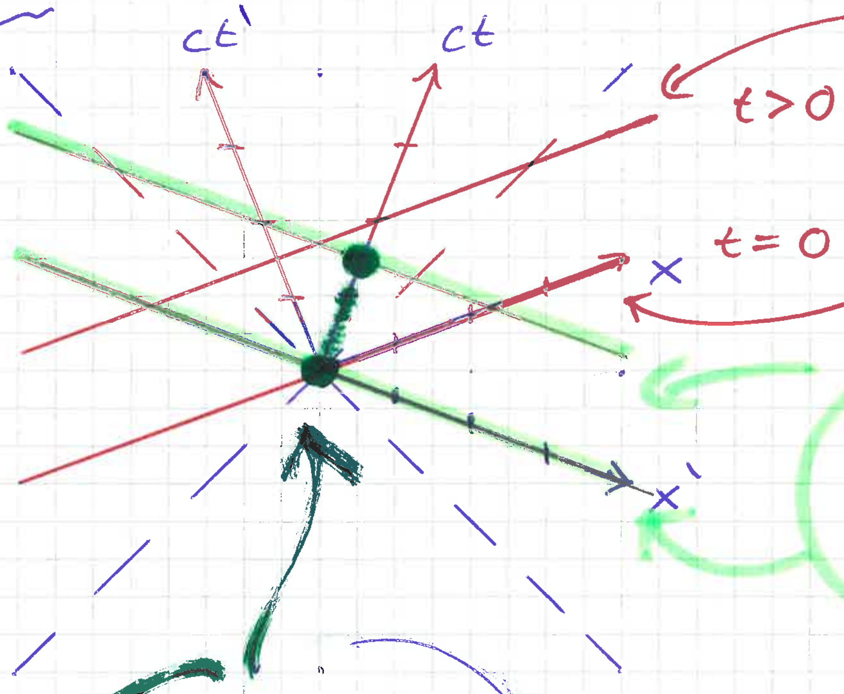


Bild - 007



kleiner Abstand zwischen Teilstrichen (nicht maßstabsgetreu, auch nicht wichtig)

Bild - 008



Gleichzeitig-keitslinien für B

Gleichzeitig-keitslinien für B'

Für B' sind bereits 2 Zeiteinheiten vergangen, während die Uhr von B nur etwa 1.5 Zeiteinheiten anzeigt

Bild - 009

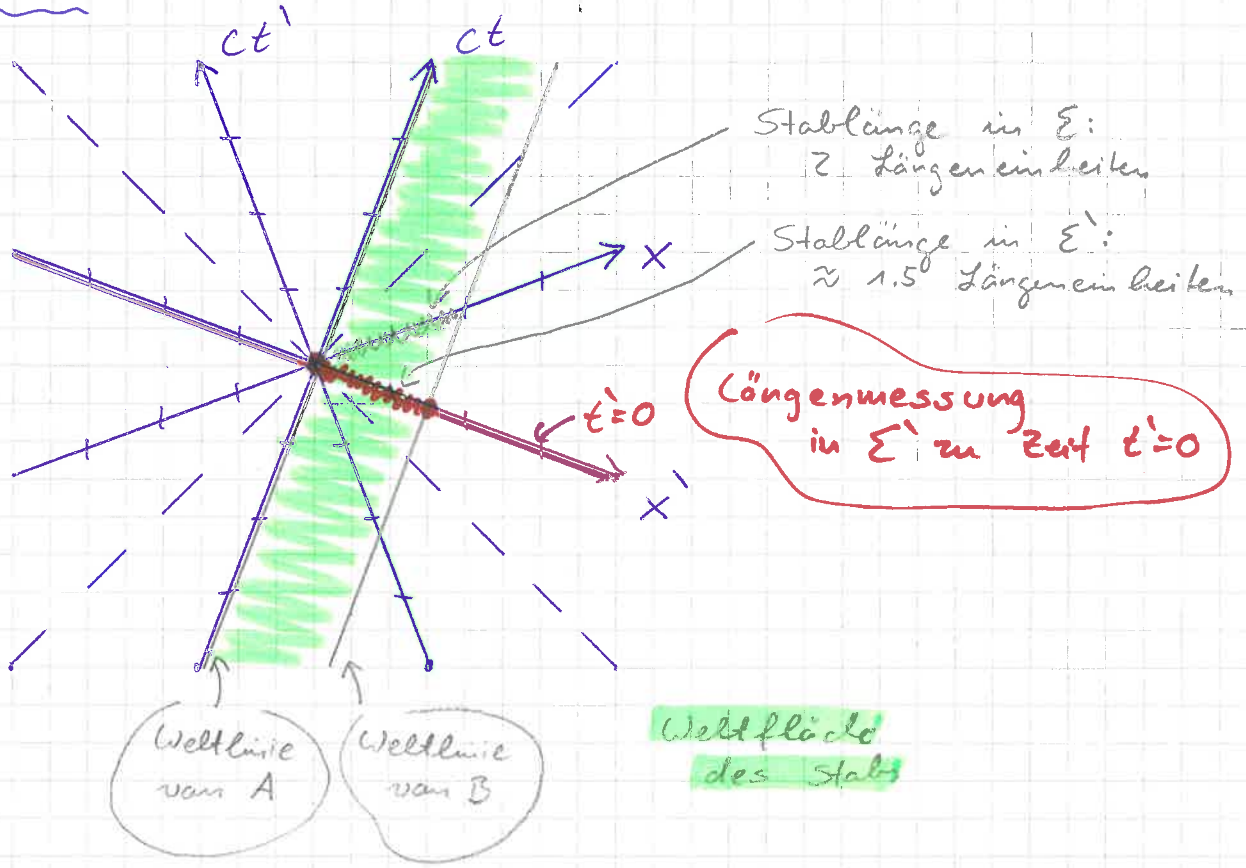
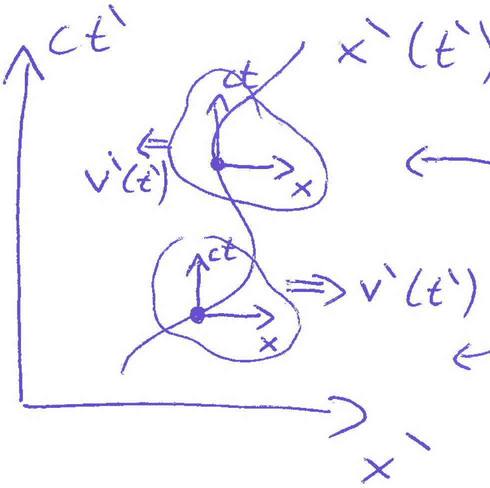

ct'
ct
x
x'
t'=0
Stablänge in Σ:
2 Längeneinheiten
Stablänge in Σ':
≈ 1.5 Längeneinheiten
Längenmessung
in Σ' zu Zeit t'=0
Weltlinie von A
Weltlinie von B
Weltfläche des Stabs

Bild - 010

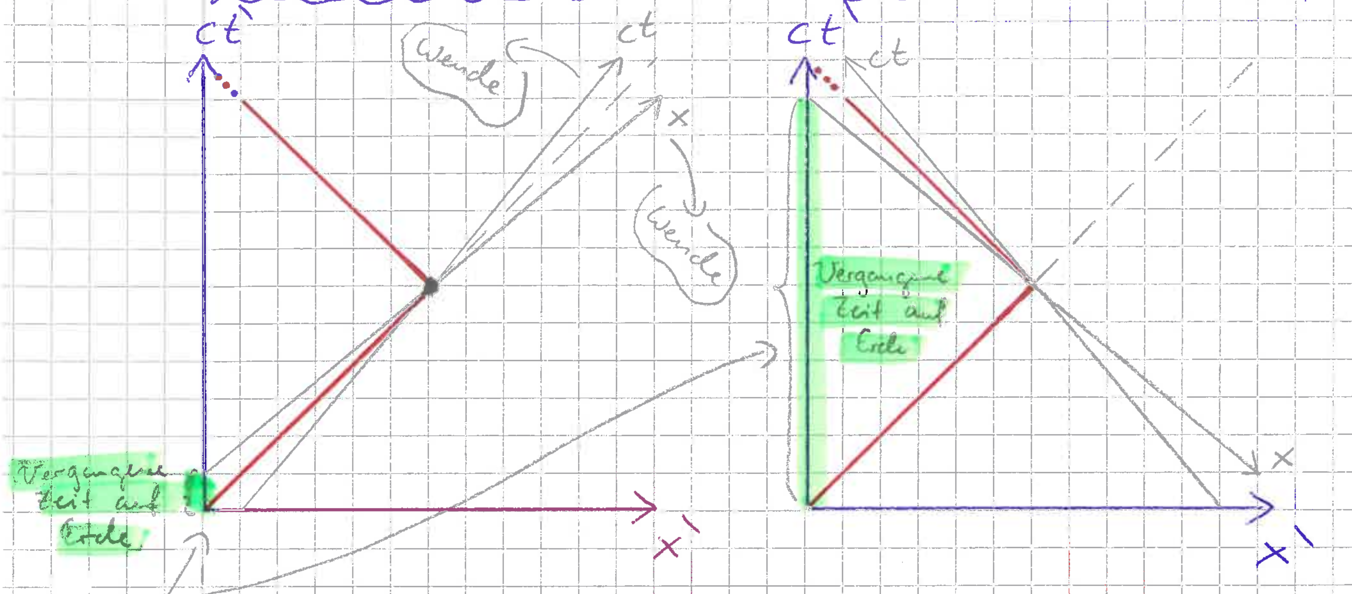


x`(t`): Weltlinie von B

für kurzen Moment v` = const, d.h. B bewegt sich mit Inertialsystem

Bild - 011

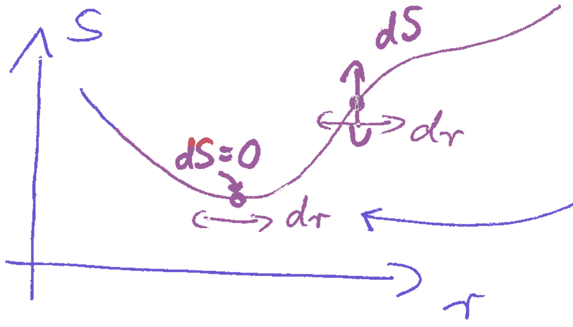
kurz vor der Wende — kurz nach der Wende



Weltlinie des Reisenden (bewegt sich mit nahezu Lichtgeschwindigkeit)

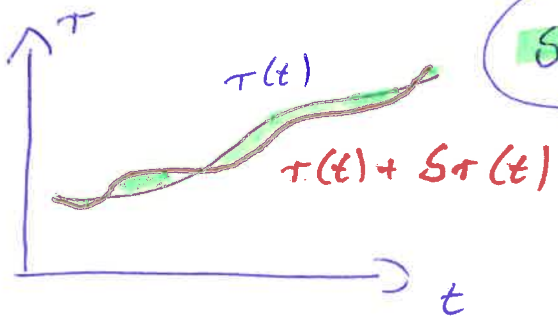
Freunde auf der Erde altern während des Wendemanövers rasant schnell

Bild - 012



dS = 0 charakterisiert Extrema von S(r).

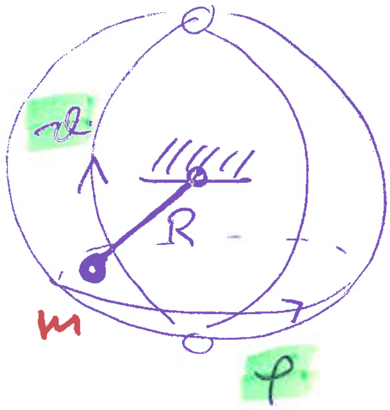
Bild - 013



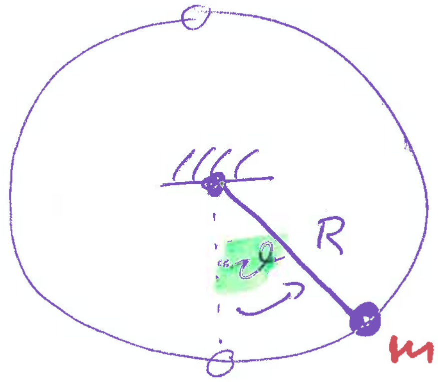
δr(t): infinitesimale Veränderung von r(t)

Bild – 014

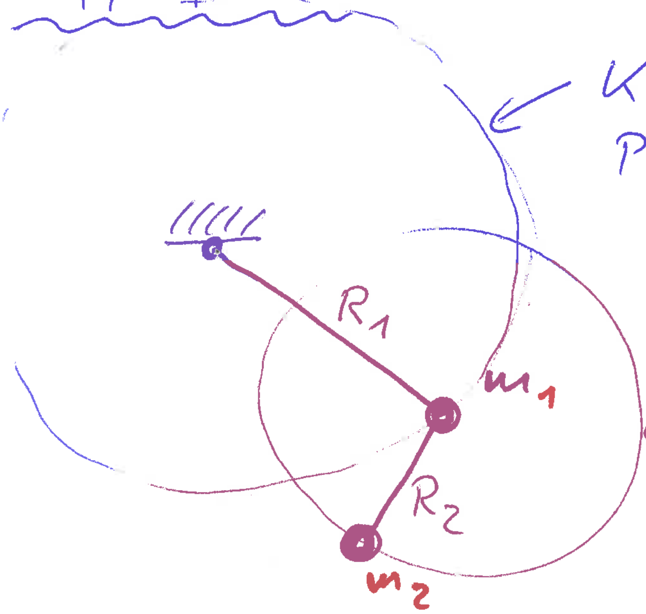
Pendel



Ebenes Pendel



Doppelpendel



Kugel, parametrisiert durch (ϑ_1, φ_1)

Kugel, parametrisiert durch (ϑ_2, φ_2)

Schraubenlinie

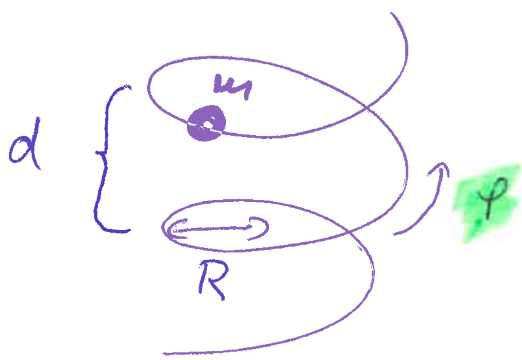
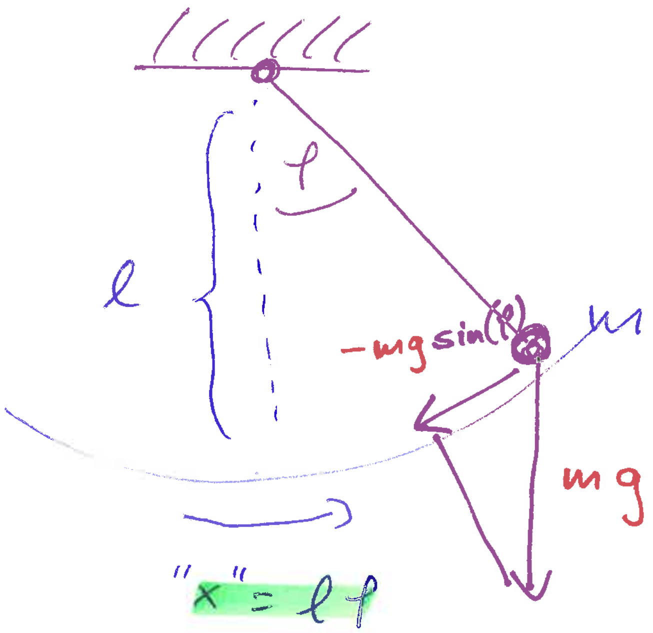


Bild – 015

"Newtonsche Überlegungen":



→ Newtonsche BGL:

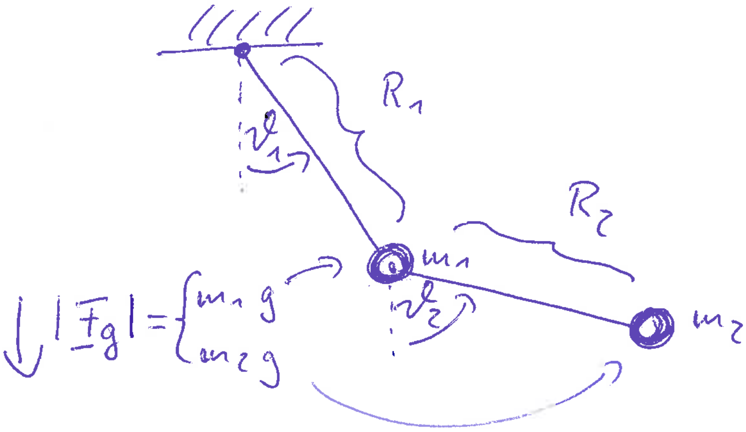
$$m\ddot{x} = F$$

$$\rightarrow m\ell\ddot{\varphi} = \boxed{-mg\sin(\varphi)}$$

$$\rightarrow \ddot{\varphi} = -\frac{g}{\ell}\sin(\varphi)$$

... o.k., konsistent mit Lagrange BGL.

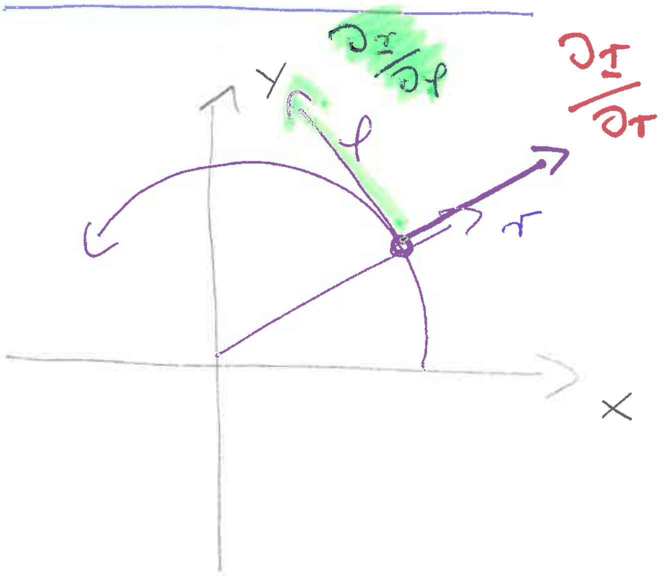
Bild 16



R_1
ϑ_1
R_2
m_1
ϑ_2
m_2
$|F_g| = \begin{cases} m_1 g \\ m_2 g \end{cases}$

Bild 17

Polarkoordinaten



$$\underline{r} = \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} r\cos(\varphi) \\ r\sin(\varphi) \end{pmatrix}$$

Kugelfläche (Radius R)

$$\underline{r} = \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} R\sin(\vartheta)\cos(\varphi) \\ R\sin(\vartheta)\sin(\varphi) \\ R\cos(\vartheta) \end{pmatrix}$$

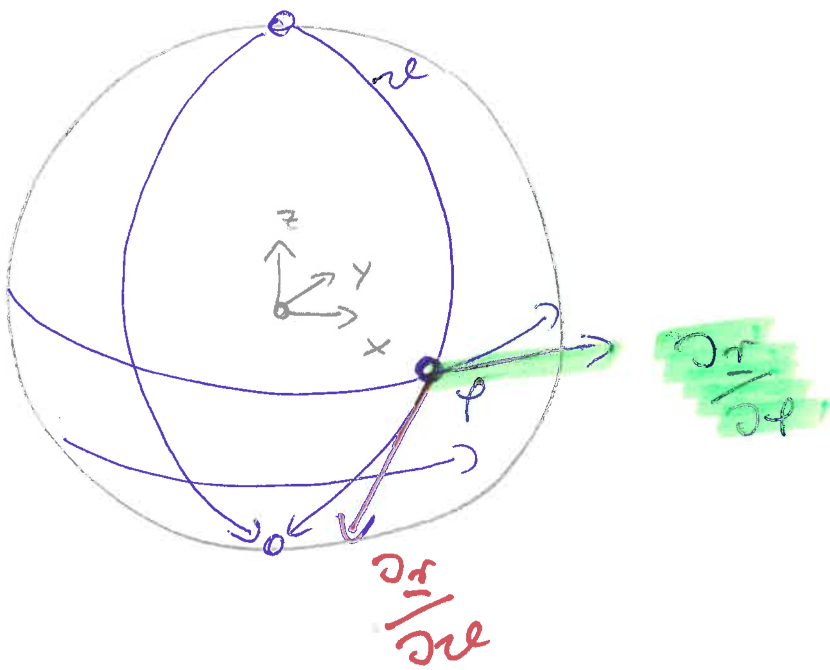
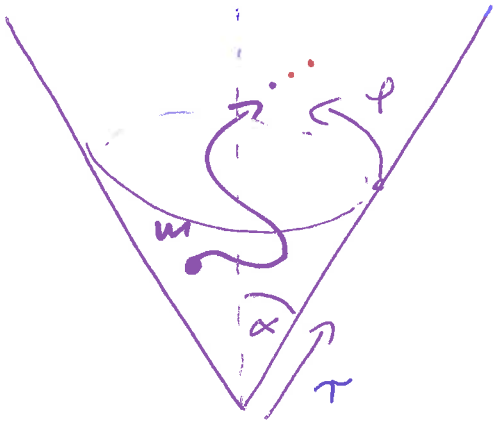


Bild - 018



Teilchenbahn auf Kegelfläche

$\downarrow |\underline{F}_g| = mg$

Bild - 019

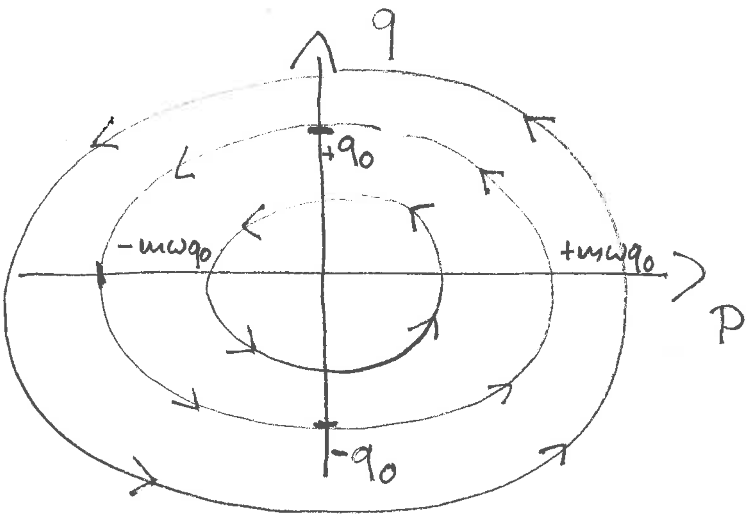
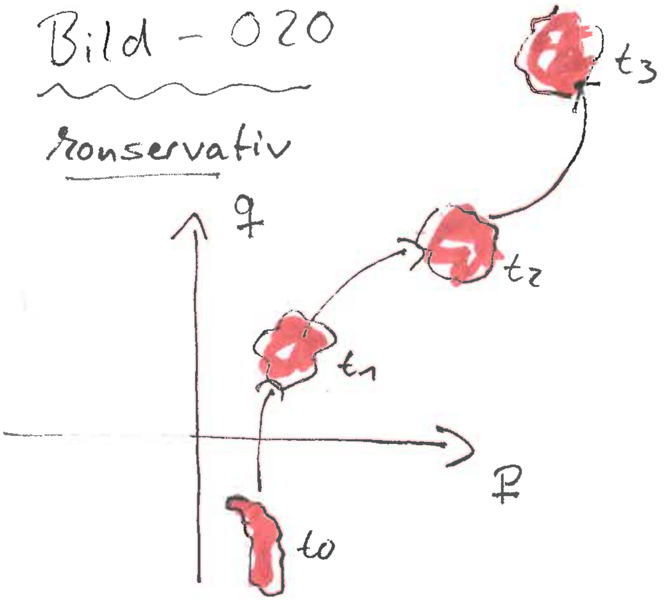


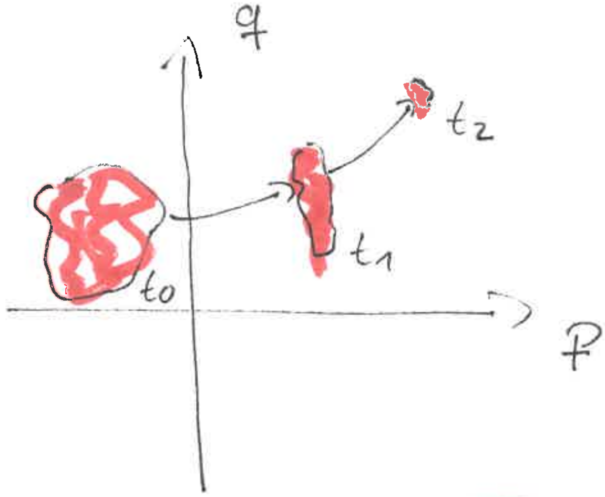
Bild - 020

konservativ



gleiches Volumen

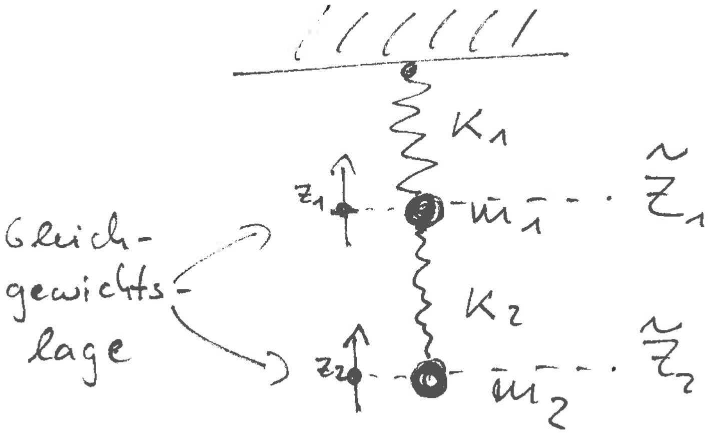
dissipativ



Volumen verkleinert sich

Bild - 021

↑ Z-Achse



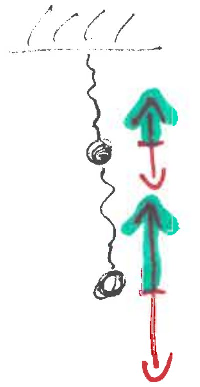
$\downarrow\ |F_g| = m_j\, g$

z_1 und z_2
beschreiben Auslenkungen
aus Gleichgewichtslage

Eigenvektor $\underline{a}_1$:

$$\underline{a}_1 = \begin{pmatrix} +1 \\ +2 \end{pmatrix}$$

$$\omega_1^2 = \frac{K}{m}$$



Eigenvektor a_2:

$$\underline{a}_2 = \begin{pmatrix} +2 \\ -1 \end{pmatrix}$$

$$\omega_2^2 = 6\,\frac{K}{m}$$

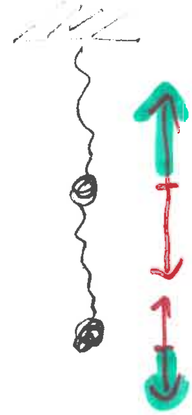
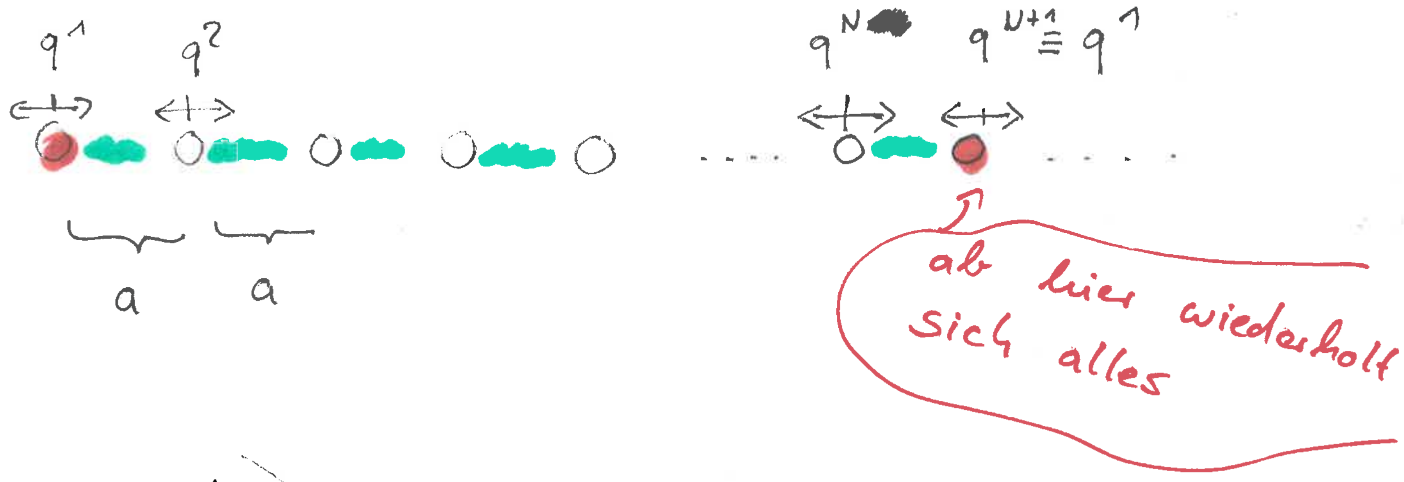


Bild - 021 , Bild - 022



$$M = \begin{pmatrix} m & & & & 0 \\ & m & & & \\ & & m & & \\ & & & m & \\ 0 & & & & \ddots \end{pmatrix} \leftarrow N \times N - \text{Matrix}$$

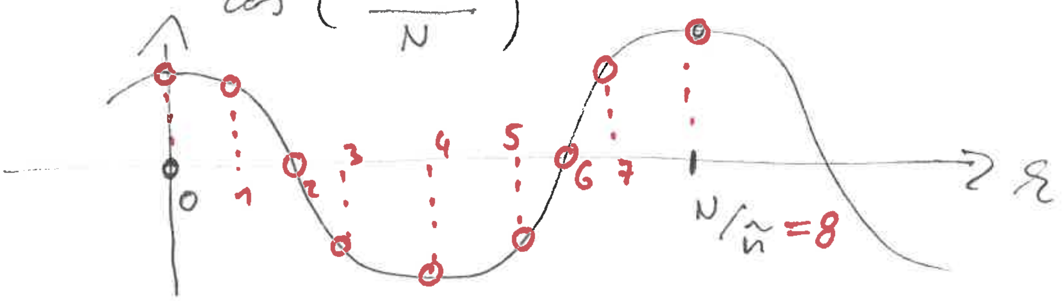
$$K = \begin{pmatrix} 2K & -K & & 0 & -K \\ -K & 2K & -K & & \\ & -K & 2K & -K & \\ & & -K & \ddots & \\ -K & 0 & & & \ddots \end{pmatrix}$$

jede nächste-Nachbar-WW gibt Beitrag

$$\begin{bmatrix} K & -K \\ -K & K \end{bmatrix}$$

Bild - 023

$\cos\left(\frac{2\pi \ell \tilde{n}}{N}\right)$



z.B. $N = 8, \tilde{n} = 1$

Bild - 024

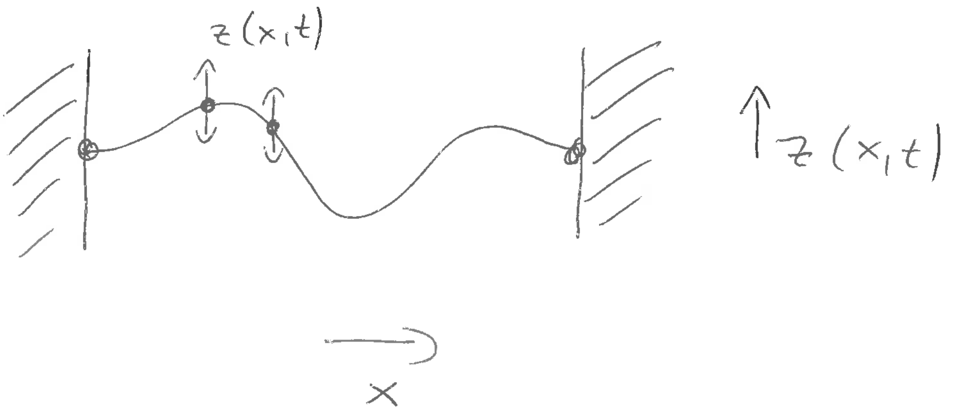


Bild - 025