Klassische Teilchen und Felder

Präsenzübung, Sheet 01 **WS 08/09 14.10.2008**

Lecture: Luis Santos – Tutorials: Garu Gebreyesus & Tobias Wirth

[P1] Linearer harmonic oscillator

A mass point of mass m moves in one dimension under the influence of a force $F_{\text{HO}} = -kx$. The initial conditions at $t = 0$ are $x(0) = 0$ and $\dot{x}(0) = v_0$. Determine $x(t)$ for $t > 0$.

[P2] Free damped oscillator

Every real oscillator will eventually come to rest because of frictional forces. We model this process with the frictional force

$$F_{\text{Re}} = -\alpha\dot{x} \quad .$$

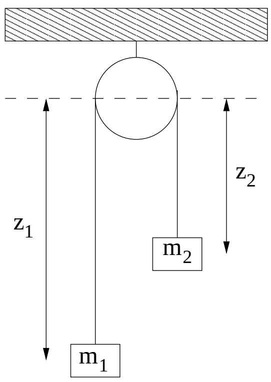
Let $\beta = \frac{\alpha}{2m}$ and $\omega_0 = \sqrt{\frac{k}{m}}$ then following equation of motion holds for the mass point:

$$\ddot{x} + 2\beta\dot{x} + \omega_0^2 x = 0 \quad .$$

- Use the anstatz $x(t) = \mathrm{e}^{\lambda t}$ and look for possible values of λ.
  Determine the general solution for $x(t)$.
- If $\beta < \omega_0$ (weak damping) you need to find $x(t) = \mathrm{e}^{-\beta t}\left[x_0 \cos\omega t + \left(\frac{v_0+\beta x_0}{\omega}\right)\sin\omega t\right]$ with $\omega = \sqrt{\omega_0^2 - \beta^2}$.
  Rewrite $x(t)$ as $x(t) = A\mathrm{e}^{-\beta t}\cos(\omega t - \phi)$.
- If $\beta > \omega_0$ (strong damping) you need to find $x(t) = -\mathrm{e}^{-\beta t}\left[a_1\mathrm{e}^{\gamma t} + a_2\mathrm{e}^{-\gamma t}\right]$ with $\gamma = \sqrt{\beta^2 - \omega_0^2}$.

[P3] Atwood's machine

Two masses m_1 and m_2 (w.l.o.g. let $m_1 \leq m_2$) are coupled with a string of constant length L. The gravitational force acts in z-direction. Remember that one has to consider the string tension S to use Newton's second law. The string tension acts against gravity and keeps the length L constant.



a) Determine the equations of motion for m_1 and m_2.

b) Calculate the accelerations $\ddot{z}_1$ and $\ddot{z}_2$.

c) What value takes the string tension S?

d) For what ratio of $\frac{m_1}{m_2}$ is S maximal?

Abgabe der Ausarbeitungen der Hausübungen ist Dienstags <u>VOR</u> der Vorlesung, d.h. bis <u>08:15 Uhr</u>. Eine spätere Abgabe ist nicht möglich!