NORGES TEKNISK-
NATURVITENSKAPELIGE UNIVERSITET
INSTITUTT FOR FYSIKK

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EXAM TFY4160 BØLGEFYSIKK
Mandag 3. desember 2007 kl. 0900 - 1300
English version

Hjelpemiddel: C

- K. Rottmann: Matematisk formelsamling (alle språk).
- O. Øgrim og B. E. Lian: Størrelser og enheter i fysikk og teknikk, eller C. Angell og B. E. Lian: Fysiske størrelser og enheter.
- Typegodkjend kalkulator, med tomt minne, i henhold til liste utarbeidd av NTNU. (HP30S eller liknende.)

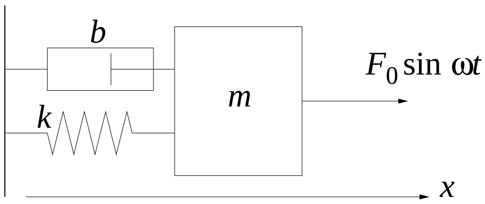
Page 2 - 6: Exercises.
Page 7 - 15: Formulas.

There are 7 questions. The weight of each question is given. Vectors are given in **bold** letters. Unit vectors are given with a hat above the symbol.

The marks are ready in early January.

OPPGAVE 1 [Counts 20%]

A mass m is connected to a spring with spring constant k. The damping force is proportional to the speed, $-b\dot{x}$. An external force $F_0 \sin \omega t$ forces the mass to oscillate back and forth with angular frequency ω.



- Show that the motion of the mass is determined by the equation

$$\ddot{x} + 2\delta\dot{x} + \omega_0^2 x = A_0 \sin \omega t,$$

and thus determine δ, ω_0 and A_0. Here, x is the displacement of the mass relative to its equilibrium position $x = 0$.

- The solution of this equation is

$$x(t) = x_0(\omega) \cos(\omega t + \phi)$$

where the frequency dependence of the amplitude is given by

$$x_0(\omega) = \frac{A_0}{\sqrt{(\omega_0^2 - \omega^2)^2 + (2\omega\delta)^2}}$$

Assume weak damping, i.e. $\delta \ll \omega_0$, and find the full width at half maximum, $\Delta\omega$, of the resonance peak, i.e., the difference between the two angular frequencies $\omega_\pm = \omega_0 \pm \Delta\omega/2$ that both result in an amplitude x_0 equal to the maximum amplitude divided by $\sqrt{2}$. (With weak damping, maximum amplitude is obtained for $\omega \simeq \omega_0$.)

Now, the speed dependent damping is replaced by ordinary friction against a surface with friction coefficient μ (the same both static and dynamic), so that there is a frictional force μmg, with direction opposite to the motion of the mass. Here, g is the acceleration due to gravity. (If the mass is at rest, the frictional force is *up to* μmg, with direction opposite to other forces trying to make the mass move.) We also turn off the external force and study free oscillations. The figure shows, as an example, the situation with $x > 0$ and $\dot{x} > 0$.