Position $x = 0$ for the mass corresponds to a spring which is not stretched or compressed. At time $t = 0$, the mass is pulled to the right, to the position $x(0) = 4.5\mu mg/k$, and released with zero initial velocity.

• Show that the motion of the mass is described by the equation(s)

$$\ddot{\xi} + \omega^2 \xi = 0$$

where we have introduced $\xi = x \pm \mu mg/k$, and where the sign depends on whether the mass moves to the right or to the left. What is the angular frequency $\omega$?

• Sketch $x(t)$ from $t = 0$ to $t = 3T/2$. Here, $T = 2\pi/\omega$ is the period of the oscillation. Give a short comment to the graph.

**OPPGAVE 2** [Counts 15%]

In this exercise, we study surface waves on deep water. These waves have the dispersion relation

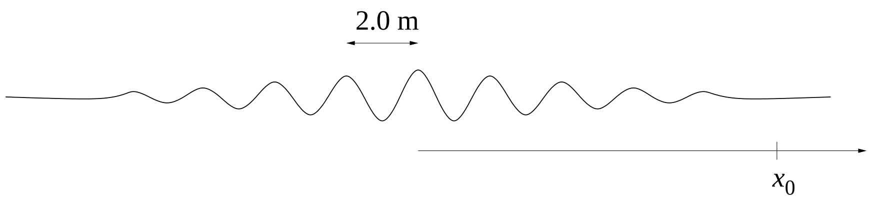
$$\omega(k) = \sqrt{gk + \gamma k^3/\rho}$$

Here, $k$ is the wave number, $g = 9.8$ m/s$^2$ the acceleration due to gravity, $\rho = 10^3$ kg/m$^3$ the mass density of water, and $\gamma = 0.073$ N/m the surface tension of water.

• Find the period of waves with wave length $\lambda = 2.0$ m.

• Find the wave lengths of waves with phase velocity $v_f = 1.0$ m/s.

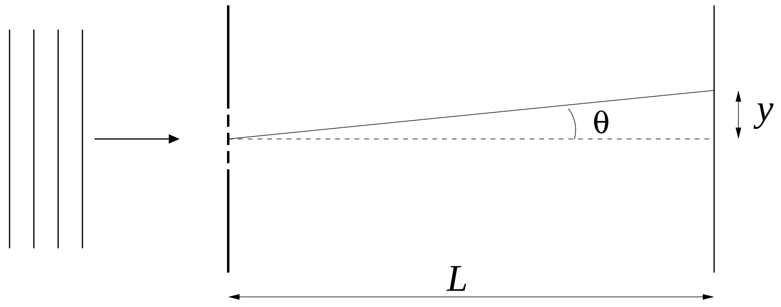
• A wave packet has 9 clear crests and wave length 2.0 m. We assume that the total length of the wave packet is 8.5 wave lengths, i.e. 17.0 m, and that the total length does not change much during our observations. The figure shows a snapshot of the wave packet:




We focus on a fixed position $x_0$ and watch carefully as the wave packet passes by. How long time does the wave packet spend in passing $x_0$? How many crests do we observe passing $x_0$? Explain your answer. (Comment: Such a spatially restricted wave packet "contains" more wave lengths than the mentioned one of 2.0 m. However, the information that the length of the packet does not change during the observations, is sufficient to answer the questions.)

**OPPGAVE 3** [Counts 15%]

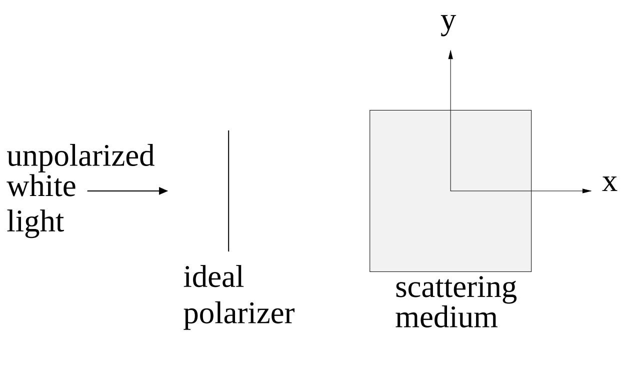
Monochromatic light with wave length $\lambda = 632.8$ nm falls perpendicularly on 4 narrow parallel slits. Each slit has width $a = 40.00$ $\mu$m, and the center-to-center distance between the slits is $d = 125.0$ $\mu$m. The light that passes through the slits falls on a screen located at a distance of $L = 300.0$ cm from the slits, and results in an intensity pattern $I(y)$. In the figure, the length direction of the slits is perpendicular to the paper plane:




• Write down an expression for the intensity pattern $I(y)$ which is valid for small angles of deviation $\theta$. In this expression, only $y$ should remain as variable parameter (in addition to the prefactor $I_0$, which represents 1/16 of the intensity in $y = 0$). Use 4 digits for numerical factors in your expression, and state the unit you have chosen for $y$ (m, cm, mm ..).

• How many zeros does $I(y)$ have all together inside the central diffraction maximum? (By "central diffraction maximum" is meant the region between $y_0$ and $-y_0$, where $y_0$ corresponds to the position of the first zero if we had only *one* slit of width $a$.) Sketch $I(y)$ for $-y_0 < y < y_0$.

**OPPGAVE 4** [Counts 10%]




Unpolarized white light is directed towards a tank containing a scattering medium. The scatterers in the tank may be regarded as induced oscillating electric dipoles with dipole moment $\boldsymbol{p}$ in the same direction as $\boldsymbol{E}$ of the incident light. (The concentration of scatterers is so small that we may disregard the possibility of scattered light being scattered again.) The incident light passes through an ideal polarizer, so that the light striking the tank has $\boldsymbol{E} \parallel \hat{y}$.

• Discuss qualitatively (and briefly) the intensity, the polarization, and the color of the light being scattered in both the $y$ and the $z$ direction.