

Exam Acoustics 2010

1 a) $\frac{\partial^2 \nabla}{\partial x^2} - \frac{1}{c^2} \frac{\partial^2 \nabla}{\partial t^2} = 0$, $c = \sqrt{\frac{E'}{\rho}} = 5064 \text{ m/s}$

b) $\nabla(x,t) = \hat{\nabla} e^{i(\omega t - kx)}$ insert in wave eqn.!

c) $t_1 = \frac{L}{c} = 0,20 \text{ ms}$ is no 1

d) no 2: $t_2 = t_1 + \frac{2L}{c} = t_1 + 0,40 \text{ ms}$ is the first reflex

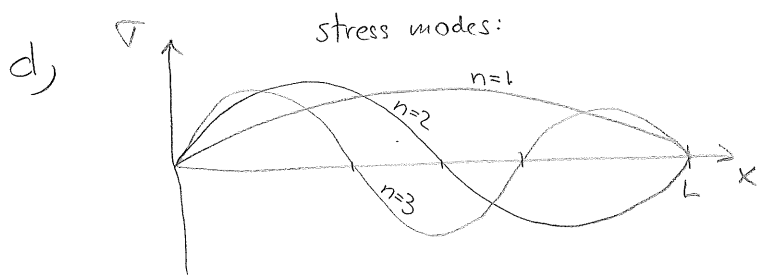
no 3: $t_3 = t_2 + \frac{2L}{c} = t_2 + 0,40 \text{ ms}$ is the second reflex

e) Knocking at the end \Rightarrow longitudinal wave \Rightarrow only sound emission at the ends
Knocking on the middle \Rightarrow bending wave \Rightarrow sound emission from the sides: loud!

2. a) Eigenfrequencies or resonance frequencies.

b) $f_n = \frac{c \cdot n}{2L} = 2470 \text{ Hz}$, 4940 Hz and 7410 Hz ($n=1,2,3$)

c) $\lambda_n = \frac{c}{f_n} = \frac{2L}{n} = 2,05 \text{ m}$, $1,025 \text{ m}$ and $0,68 \text{ m}$



e) We will have maximum displacement at the ends, zero displ. in the middle of the rod.

3. a) Nyquist criteria: you need to sample with twice the frequency in the signal $\Rightarrow f_s = 2 \cdot 7410 = 14820 \text{ Hz}$

b) Plot 2 is the frequency spectrum of plot 1, from the (fast) Fourier transform

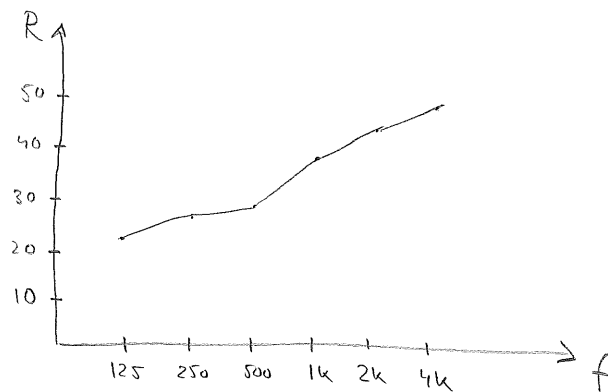
$$4. L_{p2} = 10 \log \left(10^{\frac{L_m}{10}} + 10^{\frac{L_{p0}}{10}} \right)$$

$$A = 0,16 \frac{V}{T_{60}}$$

$$\Rightarrow L_m = 10 \log \left(10^{\frac{L_{p2}}{10}} - 10^{\frac{L_{p0}}{10}} \right)$$

$$R = L_{p1} - L_m + 10 \log \left(\frac{S}{A} \right)$$

f	125	250	500	1k	2k	4k
L_{p1}	90	90	90	90	90	90
L_{p2}	70	65	60	52	46	40
L_{p0}	65	60	50	47	40	32
L_m	68,3	63,3	59,5	50,3	44,7	39,3
T_{60}	0,9	0,8	0,7	0,6	0,5	0,5
A	7,1	8	9,1	10,7	12,8	12,8
R	23,1	27,6	30,8	39,4	44,2	49,7



$$5. f_0 = \frac{1}{2L_0} \sqrt{\frac{E}{\mu_0}} \Rightarrow$$

a) $f = \frac{1}{2} f_0$

b) $f = f_0$ (f does not depend on E)

c) $f = \frac{1}{\sqrt{2}} f_0$

d) $f = f_0$ (f does not depend on force of stroke)

e) $f = \sqrt{2} \cdot f_0$

$$6. a) t = \frac{2Z_y}{Z_y + Z_{air}} \approx 2$$

$$b) \tau = \frac{4Z_y Z_{air}}{(Z_y + Z_{air})^2} \approx 0$$

$$c) r = \frac{Z_2 - Z_1}{Z_2 + Z_1} \approx 1$$

$$d) s = \frac{|Z_2 - Z_1|^2}{(Z_2 + Z_1)^2} \approx 1$$

e) There is no transmission of energy since $\tau \approx 0$, there is however a transmission of a pressure wave, but with very low particle velocity due to the high impedance Z_y .