LUND UNIVERSITY
ENGINEERING ACOUSTICS, LTH

Solutions – Ljud i byggnad och samhälle, VTAF01, 2016-08-18

Uppgift 1

1\. a) $L_{Aeq,24} = 10\log\left(\frac{1}{T}\int_0^T 10^{L_p(t)/10}\,dt\right) =$

$= 10\log\left(\frac{1}{24}\left(6\cdot10^{4,5} + 3\cdot10^{7} + 6\cdot10^{5} + 4\cdot10^{6,8} + 5\cdot10^{5}\right)\right) = \underline{63{,}7\text{ dBA}}$

b) Frifältsvärde $= 63{,}7 - 6 = 57{,}7$ dBA > 55 dBA $\underline{\text{ja!}}$

c) $L_{A-3} = 10\log\left(10^{\frac{57{,}7}{10}}\cdot 3\right) = \underline{62{,}5\text{ dBA}}$

d) Att sänka hastighetsbegränsningen minskar bullernivåerna

e) Leder till t.ex. minskad levnadsstandard (sömnsvårigheter, koncentrationsstörning...)

Uppgift 2

a) Apply simply Sabine´s law

b) Sabine´s law again putting in the lamp.

Uppgift 3

3\. a) $R = -10\log\left(\frac{1}{15}\left(13{,}5\cdot10^{-6} + 1{,}5\cdot10^{-3} + 400\cdot10^{-6}\right)\right) = \underline{38{,}9\text{ dB}}$

b) Vägg: $\tau = \frac{13{,}5}{15}\cdot10^{-6} = 9\cdot10^{-7}$ av totalt infallande effekt

Fönster: $\tau = \frac{1{,}5}{15}\cdot10^{-3} = 1\cdot10^{-4}$ —— " ——

Ventil: $\tau = \frac{400\cdot10^{-6}}{15} = 2{,}7\cdot10^{-5}$ —— " ——

Fönster (mest) – ventilationsdon – vägg (minst)

Uppgift 4

4a)

(2) The maximum sound absorption and energy loss is achieved at the points where the air moves the most, that is, where the particle velocity is maximum. Suppose we insert a thin absorber off of the wall (0'25 m out from the wall). For which frequencies can we expect high sound absorption if we assume normal incidence to the wall?

$$v(x,t) = v_+\left(t-\frac{x}{c}\right) + v_-\left(t-\frac{x}{c}\right) = v_+\left(t-\frac{x}{c}\right) - v_+\left(t-\frac{x}{c}\right) = \hat{v}_+ e^{i(\omega t - kx)} - \hat{v}_+ e^{i(\omega t + kx)} =$$

(travels right; travels left (reflected); Komplex notation)

At the wall: $v(x,t)=0 = v_+(t-\frac{x}{c}) + v_-(t-\frac{x}{c}) \Rightarrow v_+ = -v_-$

Euler formula: $\sin(y) = \frac{e^{-y} - e^{+y}}{2}$

$$= \hat{v}_+ \left(e^{-ikx} - e^{+ikx}\right)\cdot e^{i\omega t} = -2i\hat{v}_+ \sin(kx) e^{i\omega t} = 2\hat{v}_+ \sin(kx) e^{i(\omega t - \frac{\pi}{2})} \quad \text{[Eq 12]}$$

The velocity is maximum if: $|\sin(kx)| = 1 \Leftrightarrow kx = -\frac{\pi}{2} - n\pi$; (travelling left ($x<0$))

$$\text{[Eq 13]} \quad x = \frac{-\pi}{2k} - \frac{n\pi}{k} \Rightarrow x = \frac{-\pi\lambda}{2\pi \cdot 2} - \frac{n\pi\lambda}{2\pi} \Rightarrow \boxed{x = -\frac{\lambda}{4} - \frac{n\lambda}{2}} \rightarrow \lambda = \frac{x}{\left(\frac{1}{4}+\frac{n}{2}\right)}$$

$k = \frac{2\pi}{\lambda}$

Thus: $x = 0'25 \longrightarrow f = \frac{c}{\lambda} = \frac{c}{x}\left(\frac{1}{4}+\frac{n}{2}\right) \Rightarrow \boxed{f = 340 + 680n \text{ Hz}}$

4b)

(3) A tiled bathroom has a floor area of $1'65 \times 2'8\,m^2$. Calculate the five lowest eigenfrequencies of the room and its respective eigenmode. Assume that the roof is absorbent and consider only the horizontal oscillations.

From Eq. 34: $$f_{n_x,n_y,n_z} = \frac{c}{2}\sqrt{\left(\frac{n_x}{L}\right)^2 + \left(\frac{n_y}{B}\right)^2 + \left(\frac{n_z}{H}\right)^2}$$

Calculating the first five frequencies:

$$f_{10} = \frac{340}{2}\sqrt{\left(\frac{1}{1'65}\right)^2 + \left(\frac{0}{2'8}\right)^2} \Rightarrow \boxed{f_{10} = 103'3\,\text{Hz}}$$

$$f_{01} = \frac{340}{2}\sqrt{\left(\frac{0}{1'65}\right)^2 + \left(\frac{1}{2'8}\right)^2} \Rightarrow \boxed{f_{01} = 60'7\,\text{Hz}}$$

$$f_{11} = \frac{340}{2}\sqrt{\left(\frac{1}{1'65}\right)^2 + \left(\frac{1}{2'8}\right)^2} \Rightarrow \boxed{f_{11} = 119'6\,\text{Hz}}$$

$$f_{2,0} = \frac{340}{2}\sqrt{\left(\frac{2}{1'65}\right)^2 + \left(\frac{0}{2'8}\right)^2} \Rightarrow \boxed{f_{2,0} = 206'6\,\text{Hz}}$$

$$f_{2,1} = \frac{340}{2}\sqrt{\left(\frac{2}{1'65}\right)^2 + \left(\frac{1}{2'8}\right)^2} \Rightarrow \boxed{f_{2,1} = 214'82\,\text{Hz}}$$

NOTA: It would have been better to have taken instead B = 1'65 & L = 2'8 m, so that the frequencies would come in order, but it doesn't say anything in the task.

Uppgift 5

5. a) Ljudet böjs runt talarens huvud - diffraktion. Låga frekvenser hörs bäst då diffraktionen ökar med ökande våglängd (relativt hindrets storlek).

b) Resonans uppstår för vissa frekvenser mellan två motstående ytor. Med avståndet mellan ytorna kan resonansfrekvenserna räknas ut.

c) Tonerna är korrelerade och beroende på var man placerar huvudet blir det konstruktiv, resp destruktiv interferens, högre respektive lägre ljudnivå.

d) Lägg upp fritt, väg och mät samt knacka och registrera frekvensen. Då kan E-modul beräknas.

Uppgift 6

a) Apply the mass-law and substitute some values (they have to get the coincidence frequency to get the upper limit to which the mass law applies).

b) $R = L_{sending} - L_{receiving} + 10\log(A/10)$ and explain the terms.