Acoustics exercises

1. $W_S = 0.4\,W$, $r = 2\,m$

(a) Eq. 10 on M.6 : $I_0 = \dfrac{W_S}{4\pi r^2} = \dfrac{0.4}{4\pi \times 2^2} \simeq 7.96 \times 10^{-3}\ W m^{-2}$

(b) Eq. 8 on M.5 : $SIL = 10 \log_{10} \dfrac{I_0}{I_{ref}}$ where $I_{ref} = 10^{-12}\ W m^{-2}$

$\simeq 99.0\ dB\ SIL$

(c) $r_A^2 = (2\cos 30^\circ + 0.1)^2 + (2 \sin 30^\circ)^2 = 1.83^2 + 1^2 \simeq$ ~~3.66~~ 4.36 m^2 ($r_A =$ ~~1.91m~~ 2.09m)

$r_B^2 = (2\cos 30^\circ - 0.1)^2 + (2 \sin 30^\circ)^2 = 1.63^2 + 1^2 \simeq 3.66\ m^2$ ($r_B = 1.91 m$)

$I_A = \dfrac{W_S}{4\pi r_A^2}$ $\quad$ $I_B = \dfrac{W_S}{4\pi r_B^2}$

~~$ILD = 10\log_{10} \dfrac{I_B}{I_A} = \dfrac{r_A^2}{r_B^2}$~~

$\dfrac{I_B}{I_A}$ $\quad$ r

$\Delta_L = ILD = 10 \log_{10} \dfrac{I_B}{I_{ref}} - 10 \log_{10} \dfrac{I_A}{I_{ref}} = 10 \log_{10} \dfrac{I_B}{I_A}$

$= 10 \log_{10} \left(\dfrac{W_S}{4\pi r_B^2} \cdot \dfrac{4\pi r_A^2}{W_S} \right) = 10 \log_{10} \left(\dfrac{r_A^2}{r_B^2} \right)$

$= 10 \log_{10} \left(\dfrac{(2\cos 30^\circ + 0.1)^2 + (2 \sin 30^\circ)^2}{(2\cos 30^\circ - 0.1)^2 + (2 \sin 30^\circ)^2} \right) = 0.76\ dB$

2. $c = 340$ m/s

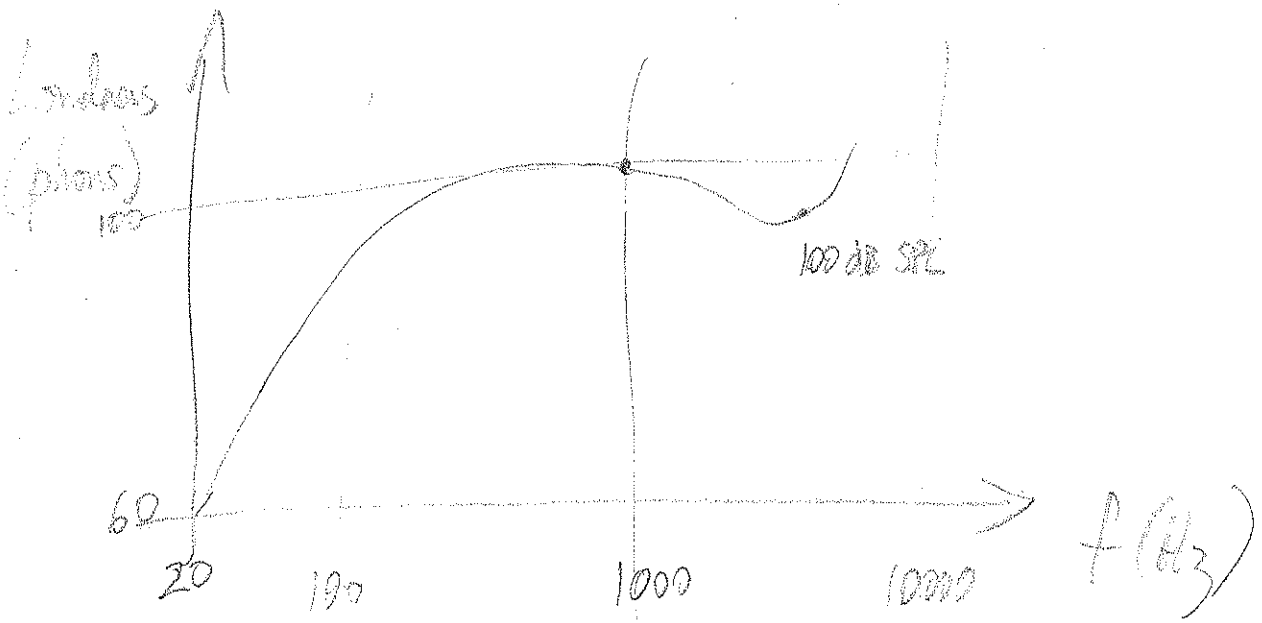
(a) $\tau_0 = \frac{r}{c} = \frac{2}{340} = 5.88$ ms or 5.9 ms

(b) $\Delta_T = ITD = \tau_A - \tau_B = \frac{r_A}{c} - \frac{r_B}{c} = 0.51$ ms

(c) $\phi = 2\pi f \Delta_T = \pi$

$\Rightarrow f = \frac{1}{2\Delta_T} = 971$ Hz or 0.97 kHz $\approx$ 1 kHz

3. See plot on L.9, where SPL = SIL from Q.1(b) and on M.11



4 (a) $E_A = 10^{\frac{90}{10}} \times 8 = 10^{\frac{99}{10}} \times T$ slide M.16

$\int p_A^2 dt = \langle p_A^2 \rangle . t$ $T = \frac{8}{10^{0.9}} \approx 1.0\,h$

(b) (i) $\frac{T}{4} \approx 15\,min$

(ii) $2T \approx 2h$

(iii) $\sim 2T \approx 2h$ (based on L.9/M.11)

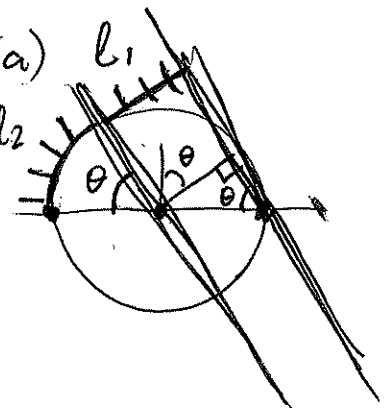
5. (a) $D = \frac{\lambda_{int}}{2} = \frac{c}{2f_{int}}$ (see N.8)

$\Rightarrow f_{int} = \frac{c}{2D} = \frac{340}{2 \times 0.2} = \underline{850\,Hz}$

(b) (i) Similar to 1(c) based on the path difference and the intensity's inverse square law (slide M.6)

(ii) strong attenuation at higher frequencies from the effect of head shadowing (slide, N.7, N.8)

6. (a)



$l_1 = r \sin\theta$

$l_2 = r\theta$

$\Rightarrow \Delta l = l_1 + l_2 = \frac{D}{2}\left(\sin\left(\frac{\pi}{3}\right) + \frac{\pi}{3}\right) = 0.19\ m$

where $D = 0.2\ m$ and $\theta = \frac{\pi}{3}$

(b) $\tau = \frac{\Delta l}{c} \simeq 0.56\ ms$

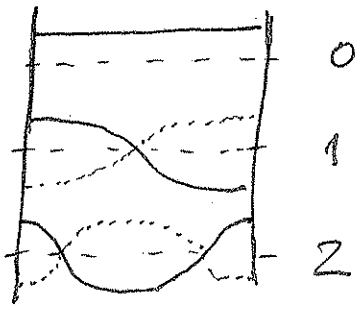
(c) $\tau = nT = \frac{n}{f_s} \Rightarrow n = \tau . f_s = 24.8 \simeq 25$ samples

	r^2	$I = \frac{W_s}{4\pi r^2}$	I (mWm^{-2})	r (m)	$\tau = \frac{r}{c}$
7. (a)	$(5 - 2\cos 30^\circ)^2 + (2\sin 30^\circ)^2 = 10.68 + 1 = 11.68$	$I' = \frac{\alpha W_s}{4\pi r^2}$	1.36	3.42	10.1 ms
(b)	$(2\cos 30^\circ)^2 + (4 - 2\sin 30^\circ)^2 = 3 + 9 = 12.0$	$I'' = \frac{\alpha W_s}{4\pi r^2}$	1.33	3.46	10.2 ms
(c)	$(5 - 2\cos 30^\circ)^2 + (4 - 2\sin 30^\circ)^2 = 10.68 + 9 = 19.68$	$I''' = \frac{\alpha W_s}{4\pi r^2}$	0.40	4.44	13.0 ms

8. $f_{ijk} = \frac{c}{2}\sqrt{\left(\frac{i}{X}\right)^2 + \left(\frac{j}{Y}\right)^2 + \left(\frac{k}{Z}\right)^2}$ (Eq. 8 on 0.13)

$c = 340$ m/s
$X = 5$ m
$Y = 4$ m
$Z = 3$ m

(1,0,0)	34.0	Hz
(2,0,0)	68.0	Hz
(0,1,0)	42.5	Hz
(0,2,0)	85.0	Hz
(1,1,0)	54.4	Hz
(2,1,0)	80.2	Hz
(1,2,0)	91.5	Hz



(a) $S = \underbrace{2\times(5+4)\times 3}_{\text{walls}} + \underbrace{2\times 5\times 4}_{\text{floor/ceiling}} = 54 + 40 = 94\ m^2$

$V = 5\times 4\times 3 = 60\ m^3$

$A = S\alpha = 0.5\times 94 = 47$ sabin

(b) critical distance $r_{crit} = \frac{1}{4}\sqrt{\frac{R_A}{\pi}}$ (Eq. 4 on 0.8)

where $R_A = \frac{S\alpha}{1-\alpha}$ (slide 0.7)

$= \frac{47}{1-0.5} = 94$

(c) $RT_{60} = \frac{KV}{S\alpha} = \frac{0.16\times 60}{47}$ (Eq. 13 on P.10)