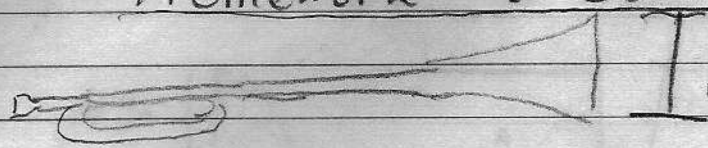
1. 0.77 sec window has drop from 86 dB to 56 dB (Praat show Intensity).
Since exponential decay, linear dB vs t, so $T_{60} = 2T_{30} \approx \underline{1.5 \pm 0.2 \text{ sec.}}$

error is large since line is not very straight.

Homework #8 Solutions (2010)

Secules/Barnett

2.



a) Bell width (or aperture width) is 17 cm.
Rule of thumb for diffraction is wavelengths larger than aperture will radiate in all directions.

$$\lambda > .17\text{ m} \qquad f < f_0$$

$$c = 340\tfrac{m}{s} = \lambda(m)\cdot f\left(\tfrac{1}{s}\right) = .17 \cdot f$$

$$f = \frac{340}{.17} = 2000\text{ Hz}\ ; \quad f < 2000\text{ Hz}$$

b) Likewise, wavelengths less than bell width beam.

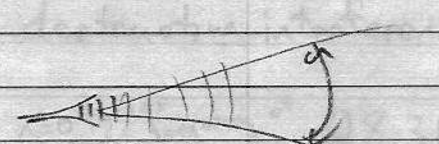
$$\lambda < .17\text{ m}$$

$$f = 2000\text{ Hz}\ ; \quad f > 2000\text{ Hz}$$

c) Listeners standing along the axis of the trombone will hear a harsher timbre, with additional high harmonics beaming out of the bell. Listeners off to the side will hear a mellower timbre, since only lower harmonics are radiating out towards them.

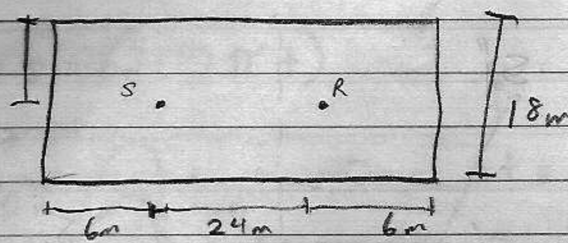
d) Angular width, $\Theta = \frac{\lambda}{D}$

$$\lambda_{20^{th}} = \frac{v}{f_{20}} = \frac{340}{20 \cdot \underset{\uparrow 400\text{ Hz}}{f}} = .0425$$



$$\theta = .0425/.17 = .25 \text{ radians} \approx 15 \text{ degrees.}$$

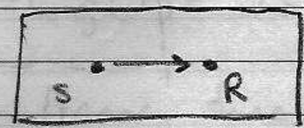
3. ~~2~~. a)



S = Source

R = Receiver

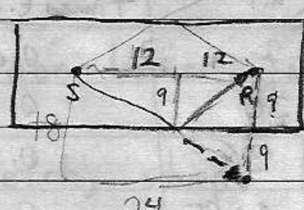
Direct path



$\Delta x = 24\,m$

$c_{sound} = \frac{\Delta x}{\Delta t} = \frac{24}{\Delta t} = 340$ $\quad \Delta t = .0706\,s = 70.6\,ms$

First reflections will be off the horizontal walls:



$\sqrt{12^2 + 9^2} = 15$

$\Delta x = 30\,m$

$c = 340 = \frac{\Delta x}{\Delta t} = \frac{30}{\Delta t}$ $\quad \Delta t = .0882\,s$

Echoes separated by $.0882 - .0706 = .0176\,s = 17.6\,ms$

b) if $L_2 - L_1 = (n + \frac{1}{2})\lambda$, will have destructive interferenc

$30 - 24 = (n + \frac{1}{2})\lambda$ $\quad$ n=0 gives lowest frequency of 28.3H

$\lambda = \frac{6}{n + \frac{1}{2}} \Rightarrow f_n = \frac{v_{sound}}{\lambda} = \frac{340 \cdot (n + \frac{1}{2})}{6}$

c) As in worksheet, find nearest source images in the lattice:

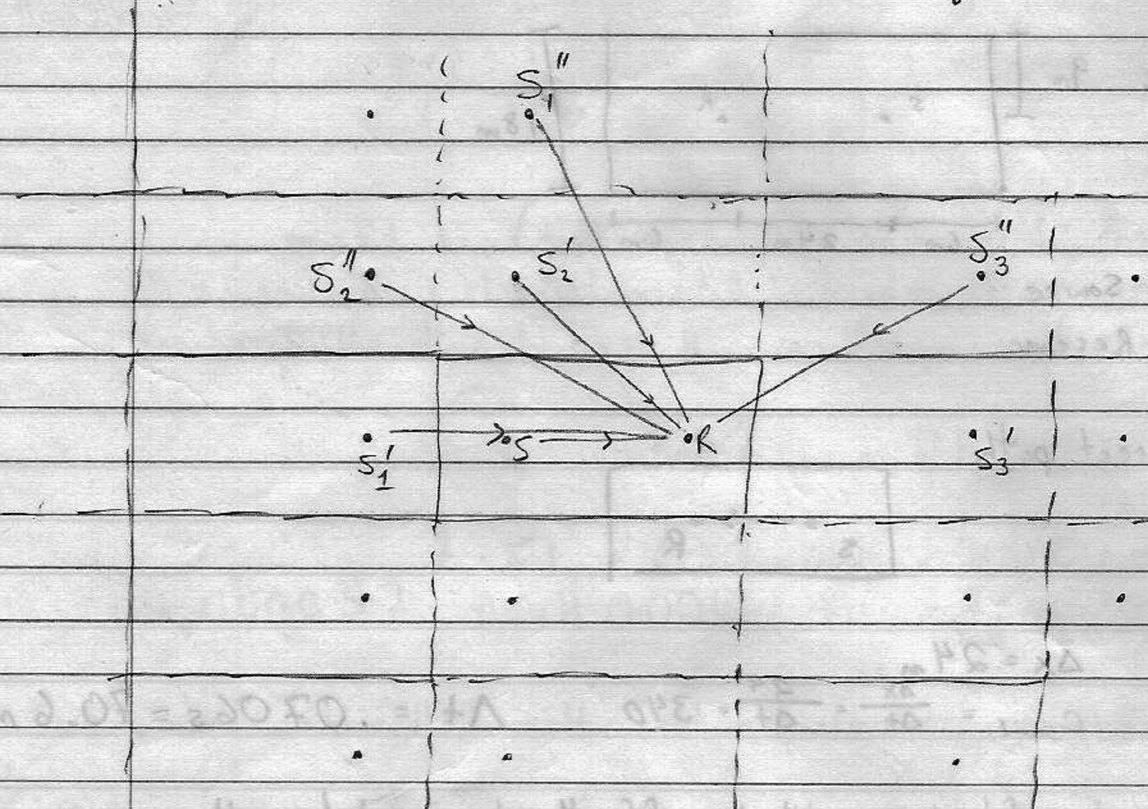


image source	Distances (m)	times (sec)	ordering
S direct	24	0.0706...	direct.
S_2' top refl.	$\sqrt{24^2+18^2} = 30$	0.0882...	1st echo
same dist. → S_1' & S_3' fwd & back	$24 + 12 = 36$	0.1059...	2nd echo (distinct arrival ti
same dist → S_2'' & S_3'' corners	$\sqrt{36^2+18^2} = 40.25$	0.1184...	3rd echo.
S_1'' top & bot.	$\sqrt{24^2+36^2} = 43.27$	0.1273...	4th echo.

Pretty tricky; imagine what it's like for a more complicated room shape.

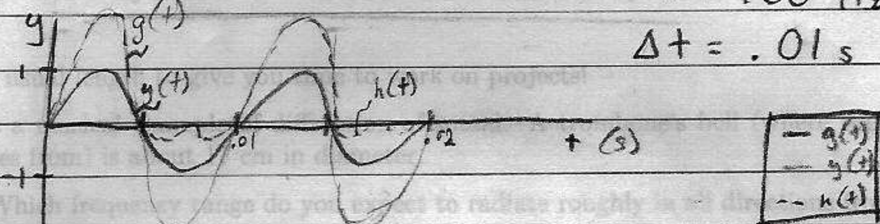
note up to the 3rd echo are within 50ms of the direct sound, so the ear melds these together.

$\boxed{4.}$ $y = f(t) = \sin(200\pi t)$

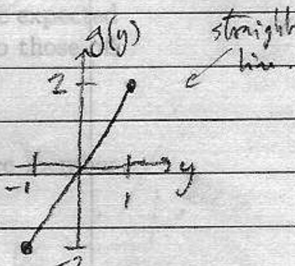
$\omega = 200\pi$

$f = 100 \text{ Hz}$

$\Delta t = .01 \text{ s}$



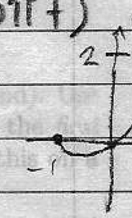
a) $g(y) = 2y \Rightarrow g(t) = 2\sin(200\pi t)$



$g(y)$ is a linear function, namely

See above sketch, signal shape is the same, only amplitude increased. No new frequencies present.

b) $h(y) = y + y^2$ $\quad h(t) = \sin(200\pi t) + \sin^2(200\pi t)$



$h(y)$ is a non-linear function, namely

See above sketch, shape has changed.

$h(t) = \underbrace{\sin(200\pi t)}_{n=1} + \underbrace{\tfrac{1}{2}}_{n=0} \underbrace{- \tfrac{1}{2}\cos(400\pi t)}_{n=2}$

$\sin^2 u = \frac{1 - \cos 2u}{2}$

$C_n = \sqrt{a_n^2 + b_n^2}$

$C_0 = \frac{1}{2}$

$C_1 = 1$

$C_2 = \frac{1}{2}$

Contains new 200 Hz frequency. Will affect the timbre, new octave above harmonic, somewhat harsher timbre: