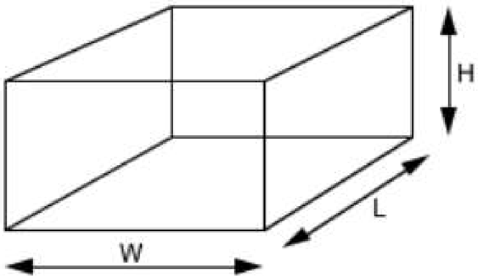
Lektion 4

Lydens opførsel i lukkede rum



1. Beregn de første 10 rum-resonanser i lyttestuen. Angiv hvilke der er aksiale. Beregn også Schröder-frekvensen og estimer efterklangstiden T60.

$$f_r = \frac{nc}{2L}$$

$$\text{Frequency} = \frac{c}{2}\sqrt{\frac{p^2}{L^2} + \frac{q^2}{W^2} + \frac{r^2}{H^2}}$$

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

$$f_S \approx 2000\sqrt{\frac{T_{60}}{V}}$$

```
% Konstanter
Lx = 5; Ly = 4; Lz = 2.5;      % Rummets dimensioner
c = 344;                       % Lydens hastighed (m/s)

f1 = (c/2) * (sqrt(((1^2)/Lx^2) + ((0^2)/Ly^2) + ((0^2)/Lz^2)))
f2 = (c/2) * (sqrt(((0^2)/Lx^2) + ((1^2)/Ly^2) + ((0^2)/Lz^2)))
f3 = (c/2) * (sqrt(((1^2)/Lx^2) + ((1^2)/Ly^2) + ((0^2)/Lz^2)))
f4 = (c/2) * (sqrt(((0^2)/Lx^2) + ((0^2)/Ly^2) + ((1^2)/Lz^2)))
f5 = (c/2) * (sqrt(((1^2)/Lx^2) + ((0^2)/Ly^2) + ((1^2)/Lz^2)))
f6 = (c/2) * (sqrt(((0^2)/Lx^2) + ((1^2)/Ly^2) + ((1^2)/Lz^2)))
f7 = (c/2) * (sqrt(((2^2)/Lx^2) + ((0^2)/Ly^2) + ((0^2)/Lz^2)))
f8 = (c/2) * (sqrt(((1^2)/Lx^2) + ((1^2)/Ly^2) + ((1^2)/Lz^2)))
f9 = (c/2) * (sqrt(((0^2)/Lx^2) + ((2^2)/Ly^2) + ((0^2)/Lz^2)))
f10= (c/2) * (sqrt(((2^2)/Lx^2) + ((1^2)/Ly^2) + ((0^2)/Lz^2)))
% Indeks
fLx = zeros(1,2);
fLy = zeros(1,2);
fLz = zeros(1,2);

% Aksiale resonanser
for n = 1:2
    fLx(n) = (n*c)/(2*Lx);
    fLy(n) = (n*c)/(2*Ly);
    fLz(n) = (n*c)/(2*Lz);
end
fLx
```

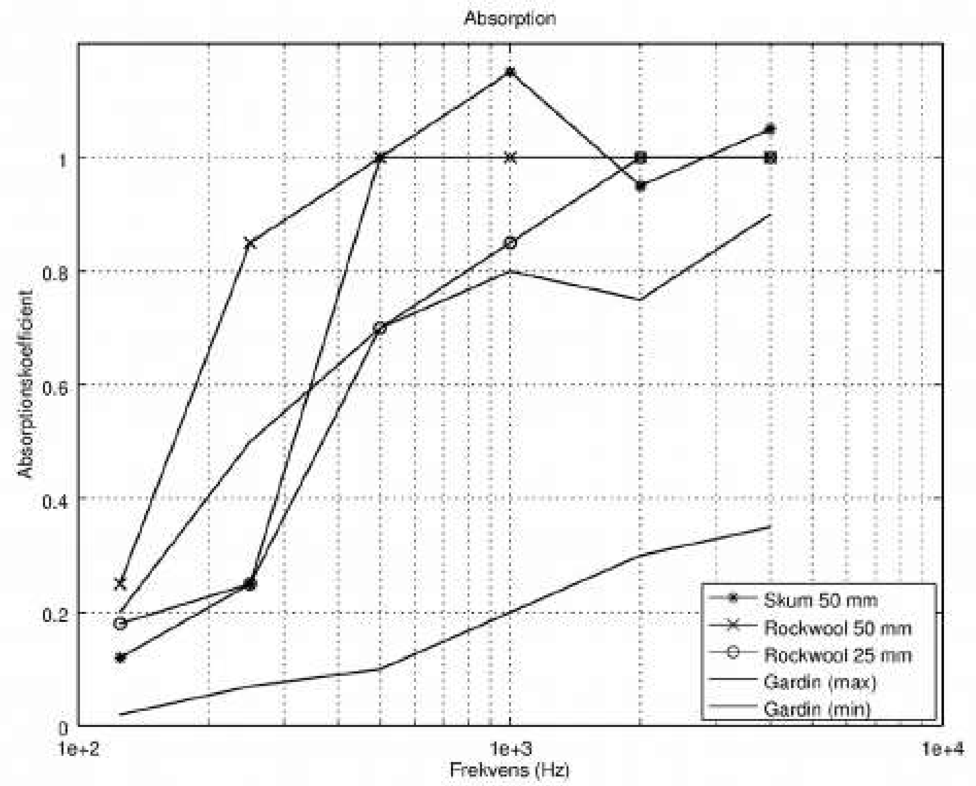
```
fLy
fLz
V = Lx*Ly*Lz;                  % Rummets volume (m3)
S = (Ly*Lz);                   % Lydabsorberende areal S (alpha for gardin)
T60 = 55.3*(V/(S*c))           % Efterklangstiden (s)
fs = 2000*sqrt(T60/V)          % Schröder frekvensen
```

2. Giv et bud på delay og relativ styrke for alle 1. ordens reflektioner (for faste kilde/lytter placeringer). Tegn impulsresponsen som søjler langs en tidsakse, hvor lyddæmpningen medtages efter afstandsreglen og eventuelt en vurdering af dæmpningen ved refleksion i fx loftplader.

```

```

3. Beregning af efterklangstiden *T*60 efter Sabine for forskellige rum. Vurdering af absorption ved brug af kurverne i "Elektroakustik" (50 – 51) eller "Report 2 – Absorber" fra Campus, eller formler fundet på nettet.

$$T_{60} = \ln(10^6)\frac{4V}{Sc} \qquad T_{60} = 55{,}3\frac{V}{Sc} \qquad T_{60} = 0{,}16\frac{V}{S} \qquad S = \alpha_1 S_1 + \alpha_2 S_2 + \dots$$




```
% Beregning af efterklangstiden
Lx = 5; Ly = 4; Lz = 2.5;          % Rummets dimensioner
V = Lx*Ly*Lz;                      % Rummets volume (m3)

disp('T60 for skum, rockwool 25mm, gardin')
alpha = [1 0.83 0.35]              % [skum, rockwool 25mm, gardin]
S = (Ly*Lz).*alpha;                % Lydabsorberende areal S

T60 = 0.16*(V./S)                  % Efterklangstiden (s)
```

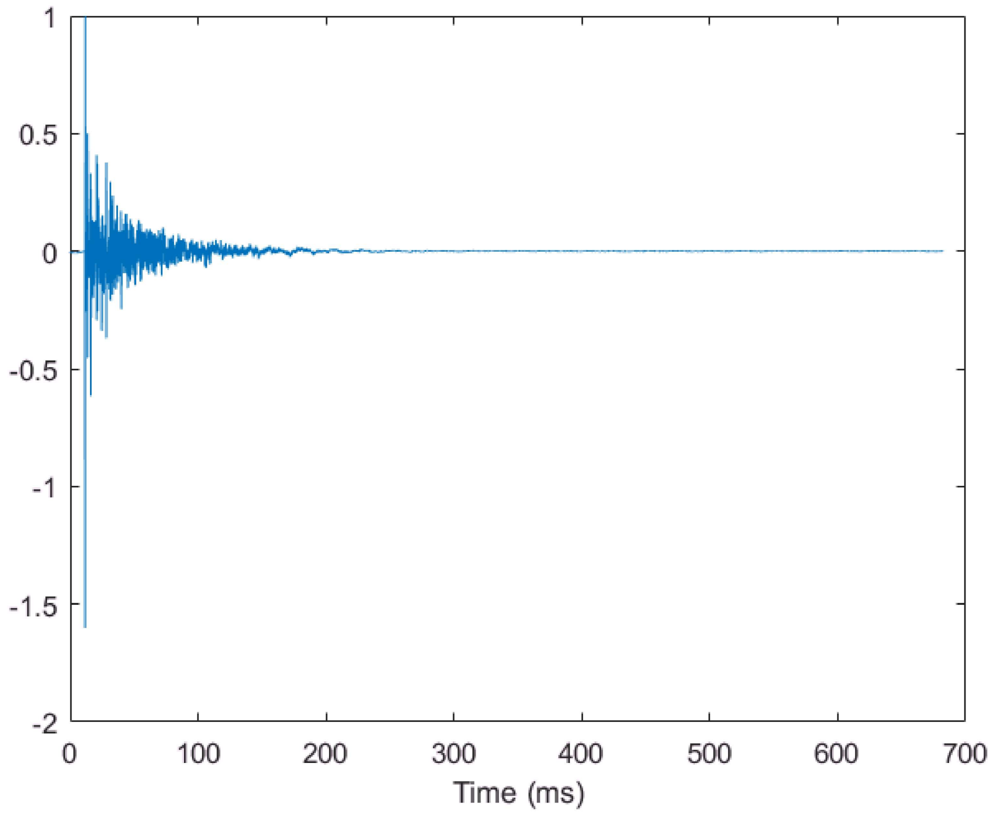
4. Bestem de rumakustiske parametre T60, EDT, og C80 ud fra impulsresponsen i filen

roomir.mat.

- **Reverberation Time:** *RT: RT60 or T60: the time it takes for the sound pressure level to fall by 60 dB after the sound has been turned off.*
- **Early Decay Time:** *EDT is derived from the Reverberation Time decay curve - the section between 0 dB and 10 dB below the initial level.*

https://dsp.stackexchange.com/questions/17121/calculation-of-reverberation-time-rt60-from-the-impulse-response/17123

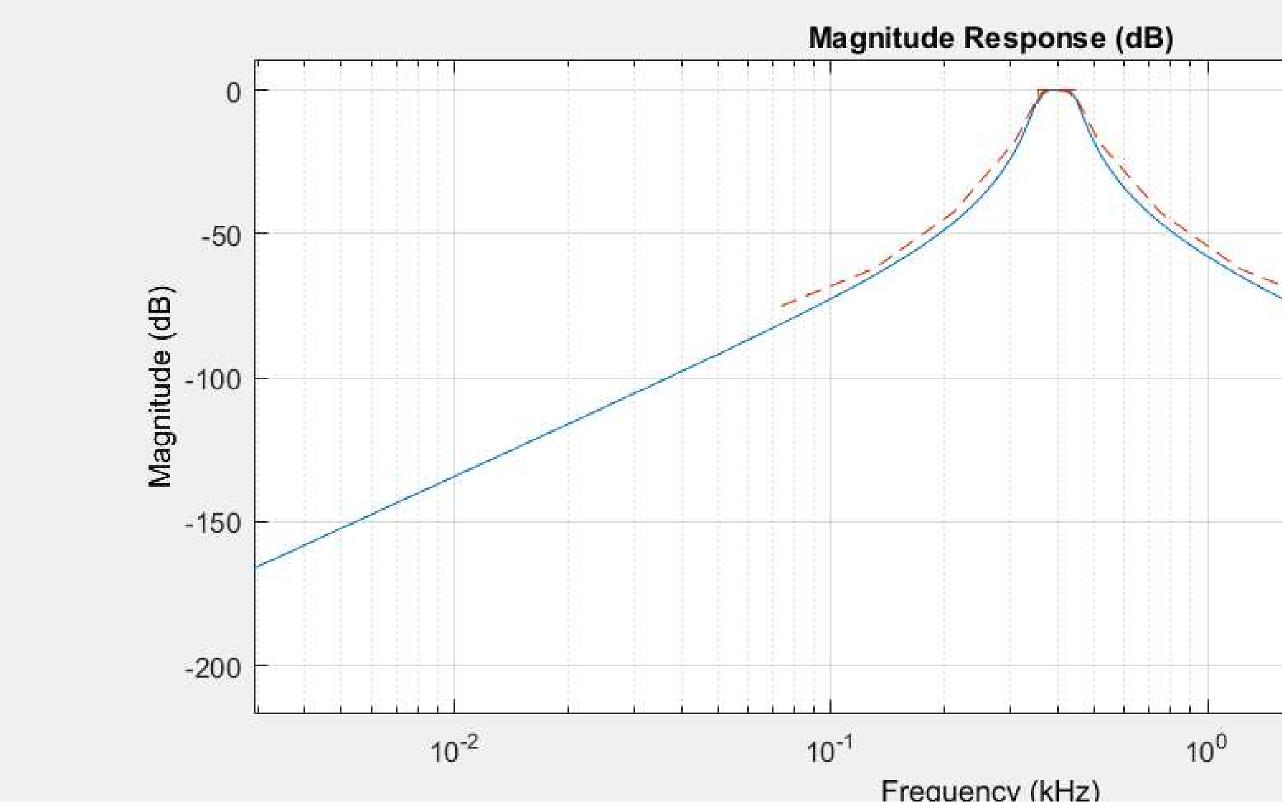
```
load roomir.mat
t=[0:length(room)-1]/48000;
figure(1)
plot(t*1e3, room/max(room))
xlabel('Time (ms)')
```



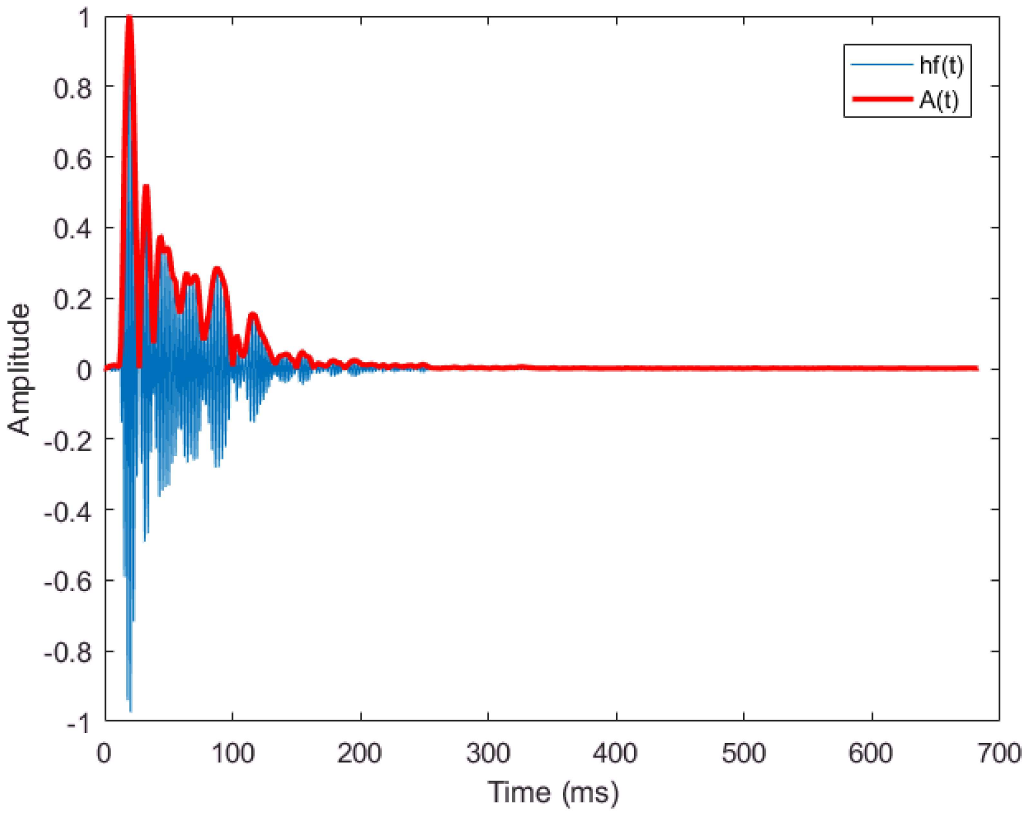

```

% 1/3 Octave filter
d = fdesign.octave(3,'Class 0','N,F0',6,398.1072,48000);
hd = design(d);
```

```
Warning: Valid values for the 'F0' property are :
25.12          31.62          39.81          50.12          63.1          79.43
100          125.89          158.49          199.53          251.19          316.23          39
 1258.93          1584.89          1995.26          2511.89          3162.28          3981.07
10000          12589.25          15848.93          19952.62
The 'F0' value has been rounded to 398.1072.
```

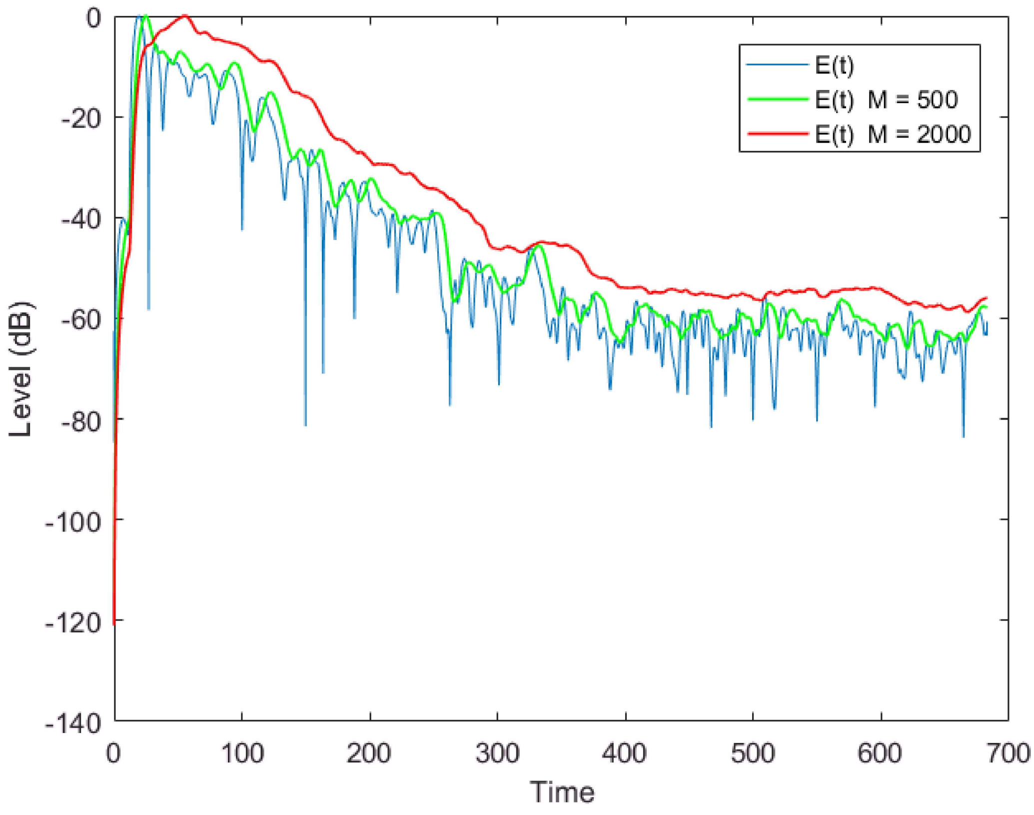
```
fvtool(hd);
```



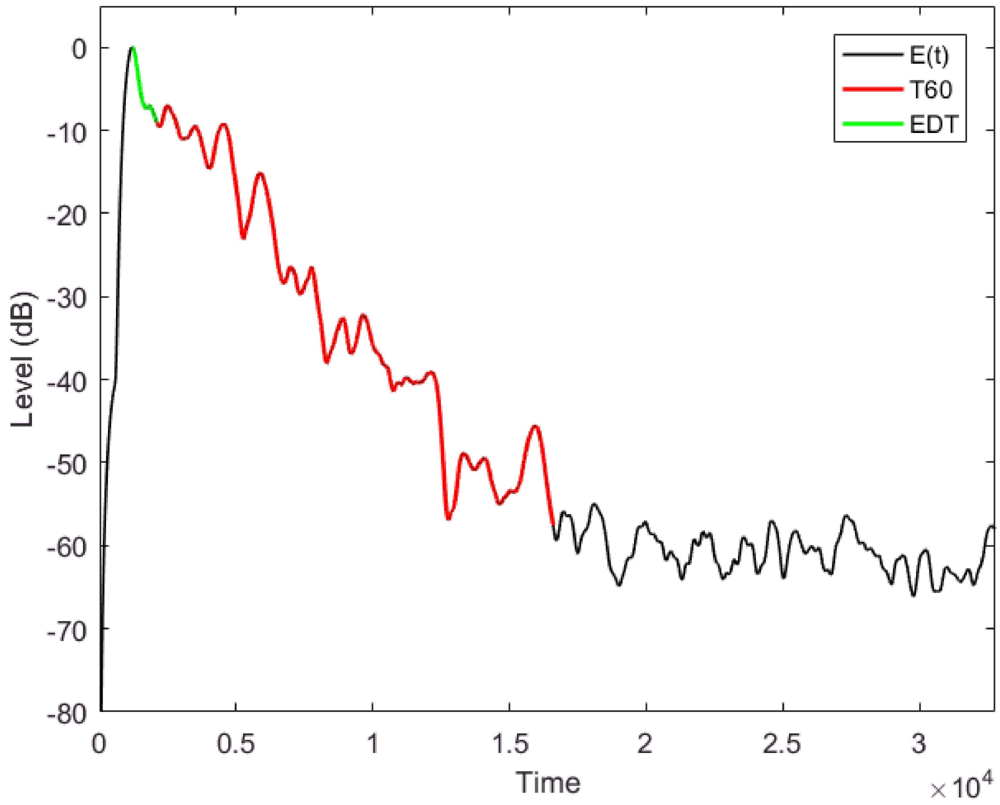

```
hf = filter(hd,room);
% Data smoothing
hA = abs(hilbert(hf));

figure(2)
plot(t*1e3, hf/max(hf))
hold on
plot(t*1e3, hA/max(hA),'r','LineWidth',2)
legend('hf(t)','A(t)')
ylabel('Amplitude'), xlabel('Time (ms)')
hold off
```




```
% Moving average
m500 = 500;
m2000 = 2000;
h500 = 1/(m500) * ones(1,m500);
h2000 = 1/(m2000) * ones(1,m2000);

e500 = filter(h500, 1, hA);
e2000 = filter(h2000, 1, hA);

figure(3)
plot(t*1e3, 20*log10(hA/max(hA)))
hold on
plot(t*1e3, 20*log10(e500/max(e500)), 'g','LineWidth',1)
hold on
plot(t*1e3, 20*log10(e2000/max(e2000)),'r','LineWidth',1)
legend('E(t)','E(t)  M = 500', 'E(t)  M = 2000')
ylabel('Level (dB)'), xlabel('Time')
hold off
```




```
figure(4)
plot(20*log10(e500/max(e500)), 'black','LineWidth',1)
hold on
plot((1197:16597),20*log10(e500(1197:16597)/max(e500(1197:16597))), 'r','LineWidth',1.5)
hold on
plot((1197:2088),20*log10(e500(1197:2088)/max(e500(1197:2088))), 'g','LineWidth',1.5)
legend('E(t)', 'T60', 'EDT')
ylabel('Level (dB)'), xlabel('Time')
axis([0 32768 -80 5])
hold off
```




```
EDT = (2088-1197)/48000*1e3
```

EDT = 18.5625

```
T60 = (16597-1197)/48000*1e3
```

T60 = 320.8333