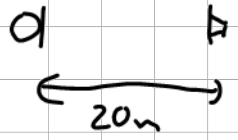
1) LTI - Liner Time Invariant

2)



$$T = \frac{20\,m}{343\,\frac{m}{s}} = 58{,}3\ ms$$

3) The FIR lowpass is symmetric arond the maximum.

$\Rightarrow$ Delay is $\left\lfloor \frac{N}{2} \right\rfloor = 250$ samples

„rounding down brackets"

$$\Rightarrow \quad T = \frac{250}{48000 \, \frac{1}{s}} = 5{,}21 \text{ ms}$$

4) $$\text{Delay} = \frac{\int_{-\infty}^{\infty} t \cdot |h(t)| \, dt}{\int_{-\infty}^{\infty} |h(t)| \, dt} = \frac{\int_{-\infty}^{\infty} t \; \varepsilon(t) \cdot \frac{1}{\tau} e^{-\frac{t}{\tau}} \, dt}{\int_{-\infty}^{\infty} \varepsilon(t) \cdot \frac{1}{\tau} e^{-t/\tau} \, dt}$$

$$= \frac{\int_{0}^{\infty} t \, e^{-t/\tau} \, dt}{\int_{0}^{\infty} e^{-t/\tau} \, dt}$$

From Bronstein: $\int x e^{ax} dx = \frac{e^{ax}}{a^2}(ax - 1)$

with $t \mathrel{\hat{=}} x$ and $a \mathrel{\hat{=}} -\frac{1}{\tau}$

$$= \frac{\left[e^{-t/\tau} \tau^2 \left(-\frac{t}{\tau} - 1 \right) \right]_0^{\infty}}{\left[-\tau \, e^{-t/\tau} \right]_0^{\infty}}$$

$$= \frac{0 - 1 \cdot \tau^2 (0 - 1)}{0 - (-\tau \cdot 1)}$$

$$= \tau$$

5)

$$\text{Delay} = \frac{0 \cdot 1 + 1 \cdot 2 + 2 \cdot 4 + 3 \cdot 2 + 4 \cdot 1}{1 + 2 + 4 + 2 + 1} = \frac{20}{10} = 2$$