

# PHY 117 HS2024

Week 12, Lecture 1

Dec. 3rd, 2024

Prof. Ben Kilminster

Last time, standing waves:  
in general

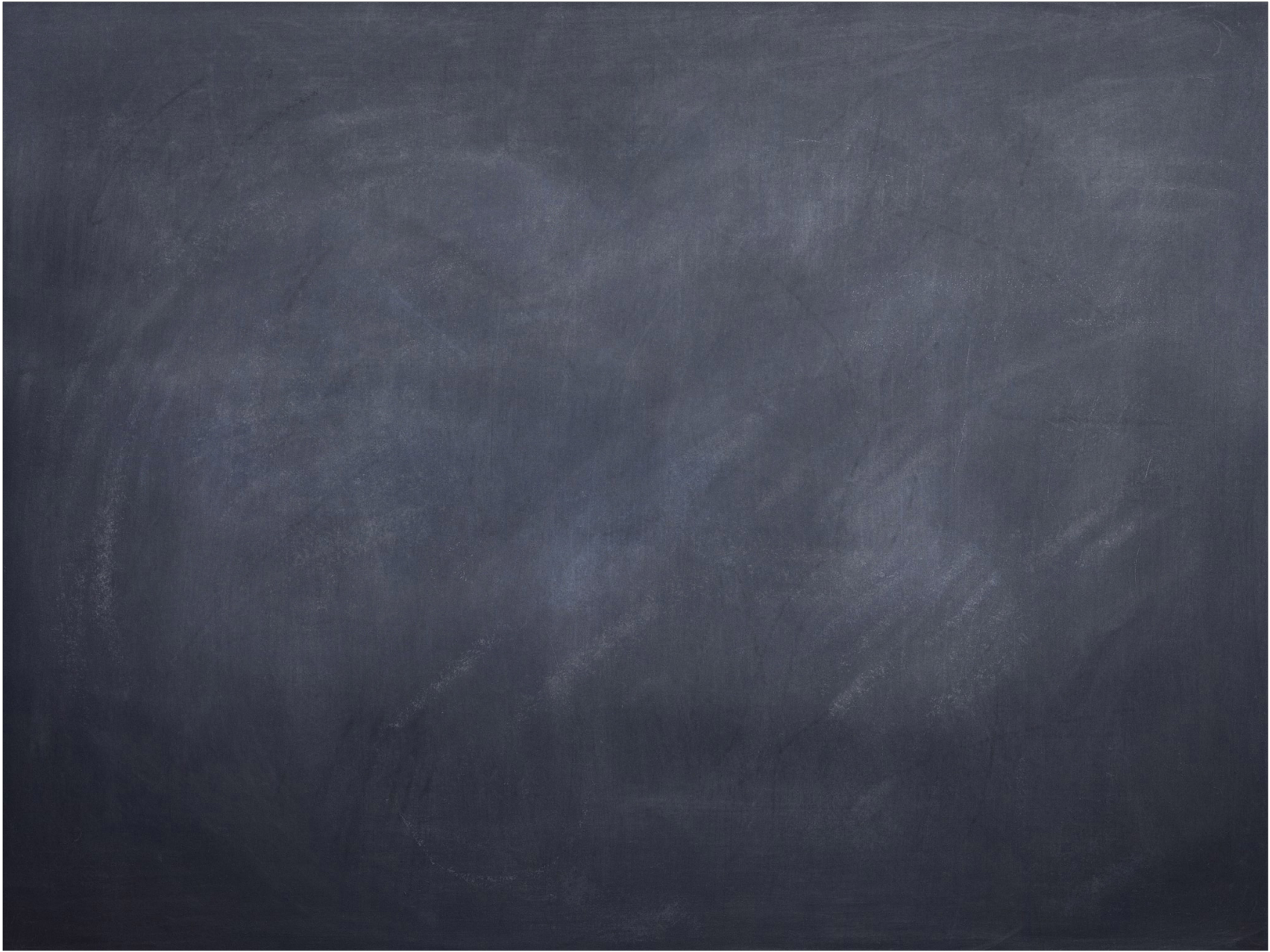
$$y(x,t) = 2A \cos \omega t \sin kx$$

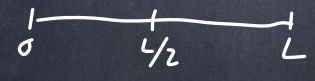
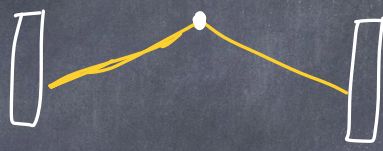
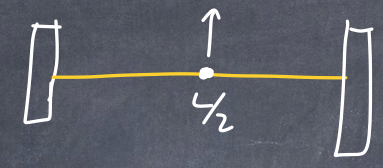
$$\text{where } k_n = \frac{n\pi}{L} + \omega_n = k_n v + v = \frac{\omega}{k}$$
$$\omega_n = 2\pi n f_1$$

$$f_1 = \frac{v}{\lambda_1} = \frac{k_1 v}{2\pi}$$

Example:  
standing  
wave  
on string

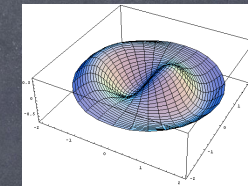
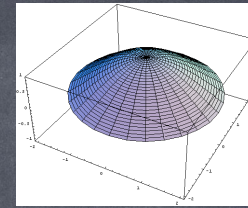
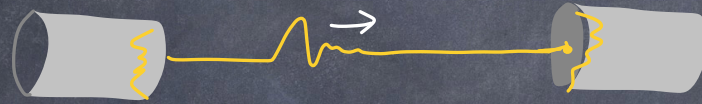






# Standing waves on a flat, round surface: diaphragm


$T$ : tension





## Wavelengths for Different States

For a hydrogen atom:

Electron wave resonance

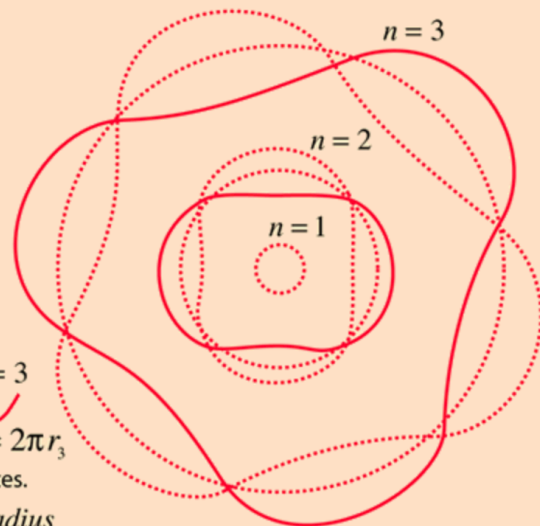
$n = 1$   

 $\lambda_1 = 2\pi r_1 = 6.28a_0$

$n = 2$   

 $2\lambda_2 = 2\pi r_2$   
 $\lambda_2 = 12.57a_0$

$n = 3$   

 $3\lambda_3 = 2\pi r_3$   
 $\lambda_3 = 18.85a_0$

Wavelengths for hydrogen states.

$a_0 = 0.0529\text{nm} = \text{Bohr radius}$



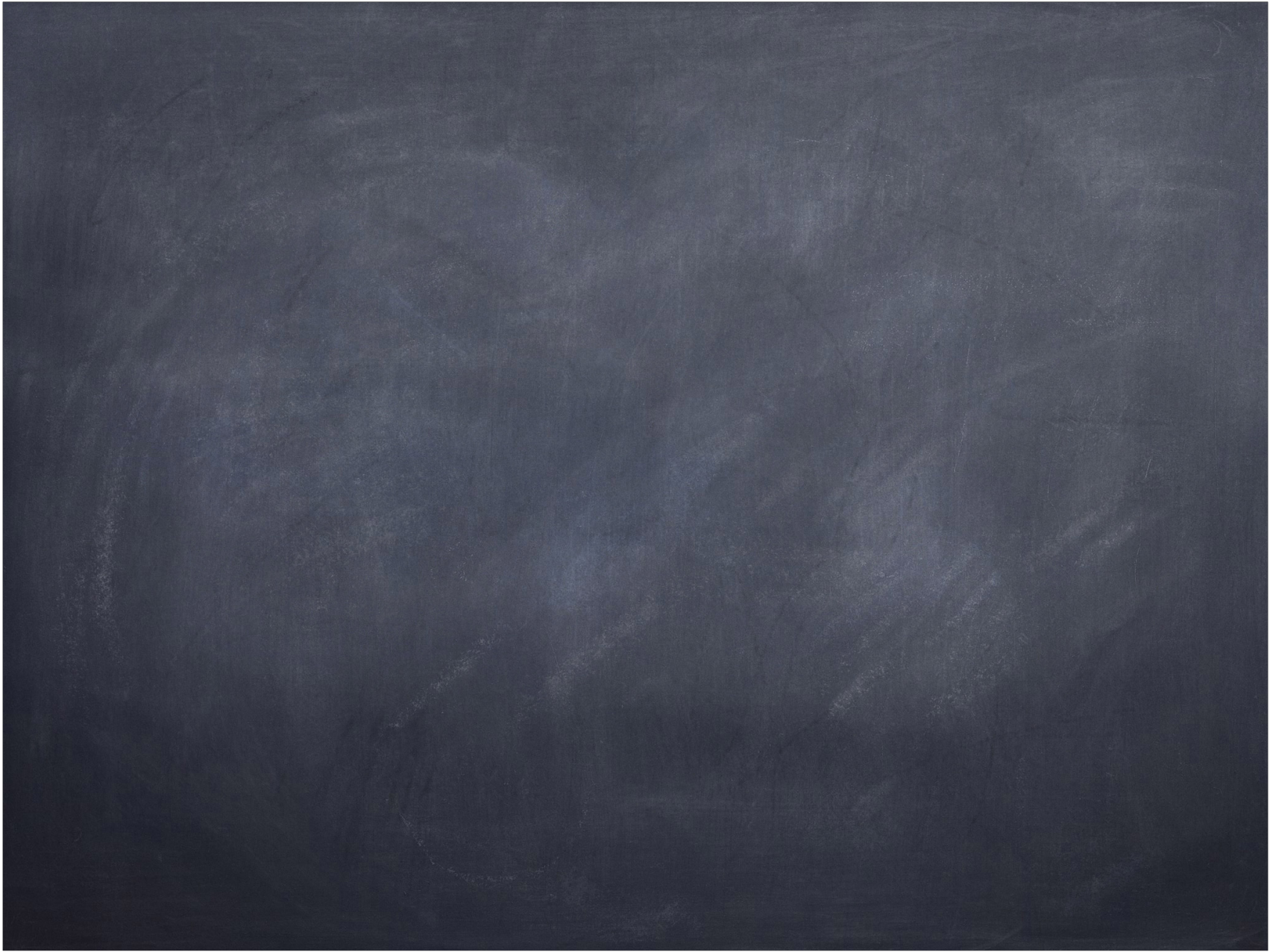
[Bohr model of the atom](#)

[Index](#)

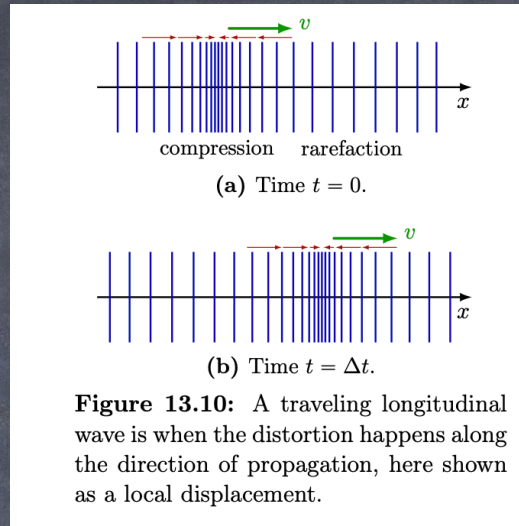
[Bohr model concepts](#)

# Energy transmission in a wave (on a string)





# Longitudinal waves



**Figure 13.10:** A traveling longitudinal wave is when the distortion happens along the direction of propagation, here shown as a local displacement.

air molecules

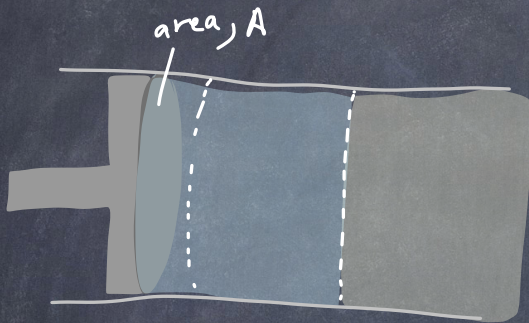


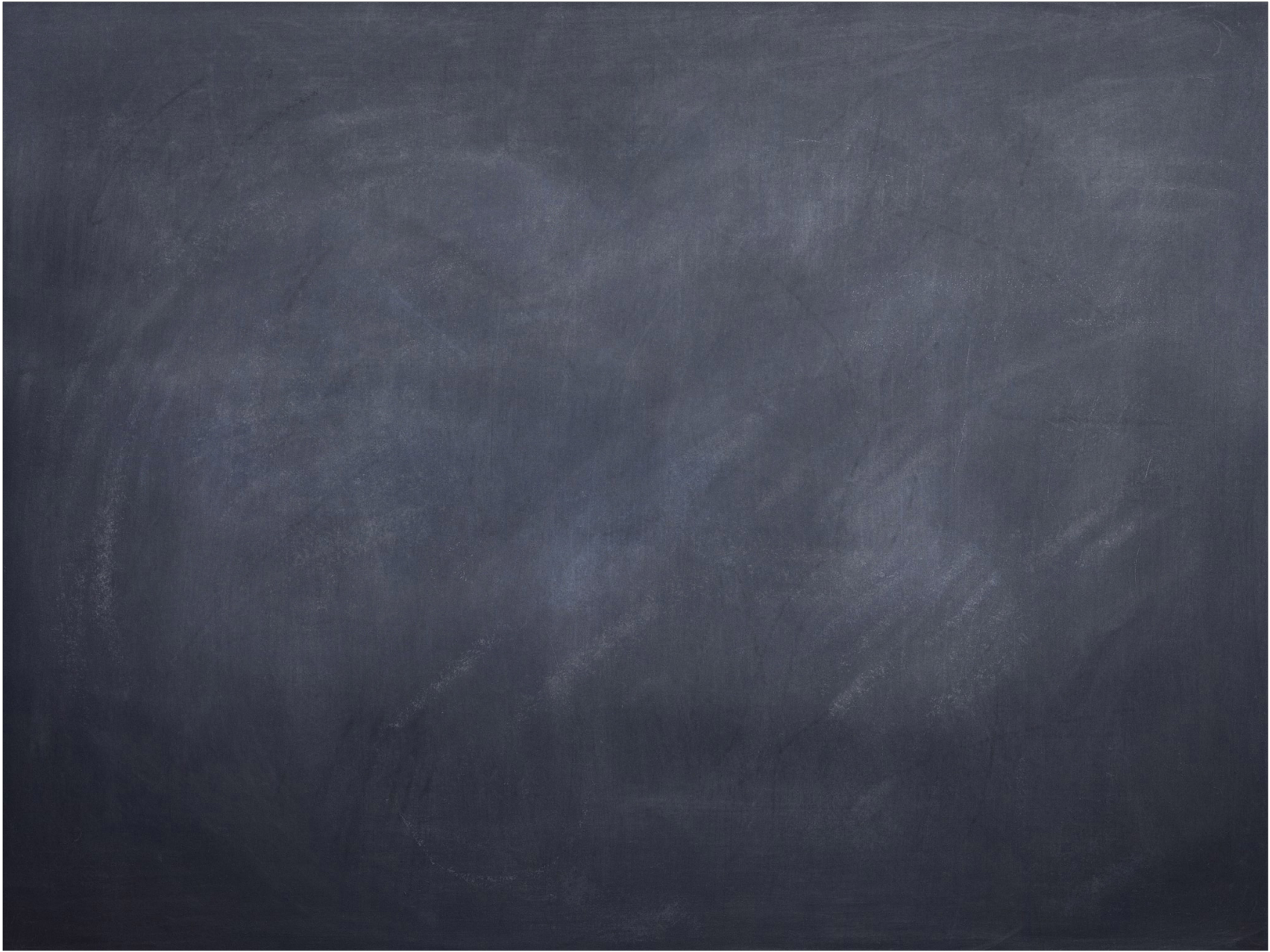


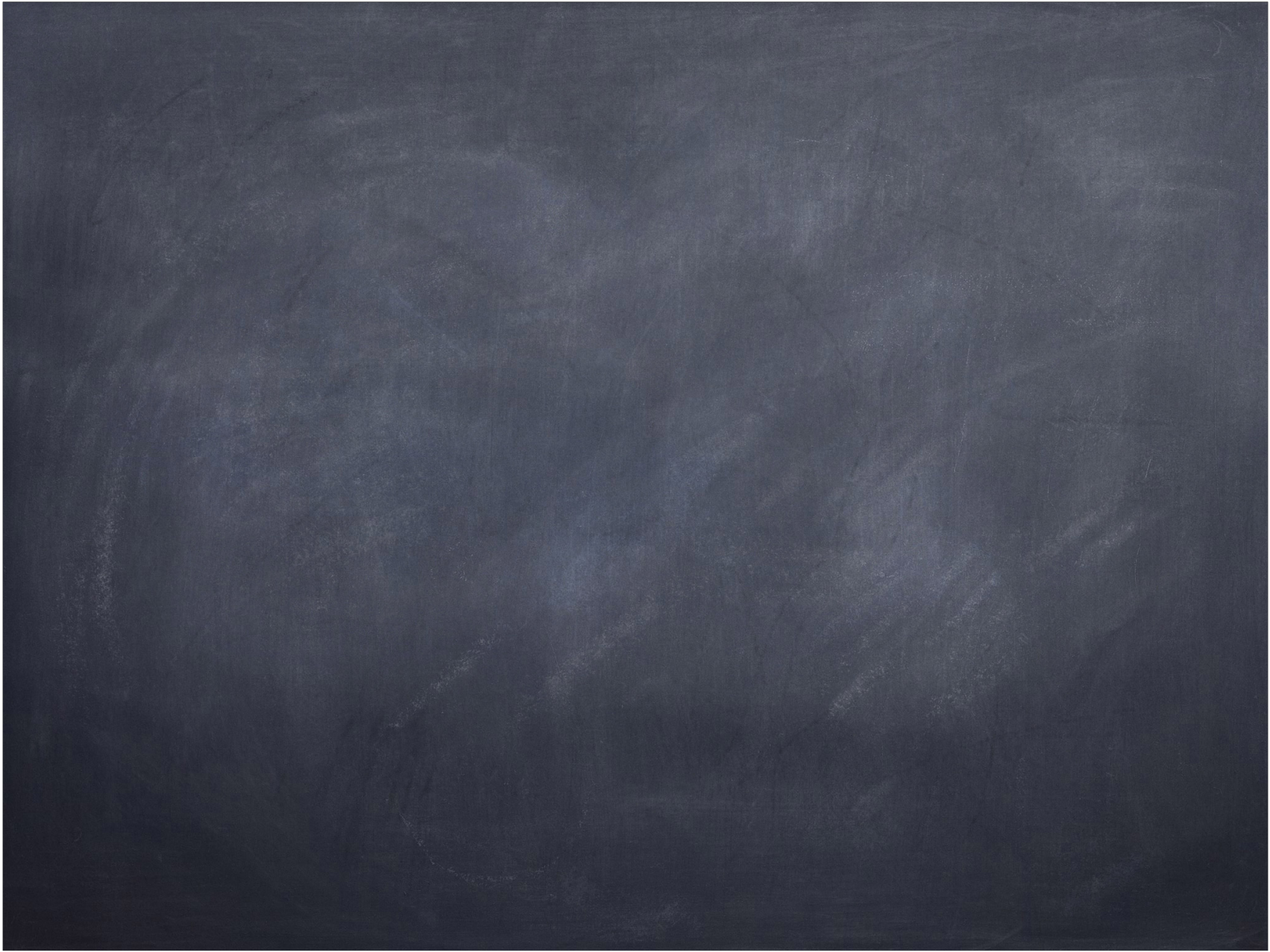
What is sound? A pressure increase  $\Delta P$  that moves with a velocity that depends on medium.

How fast is sound in a fluid?

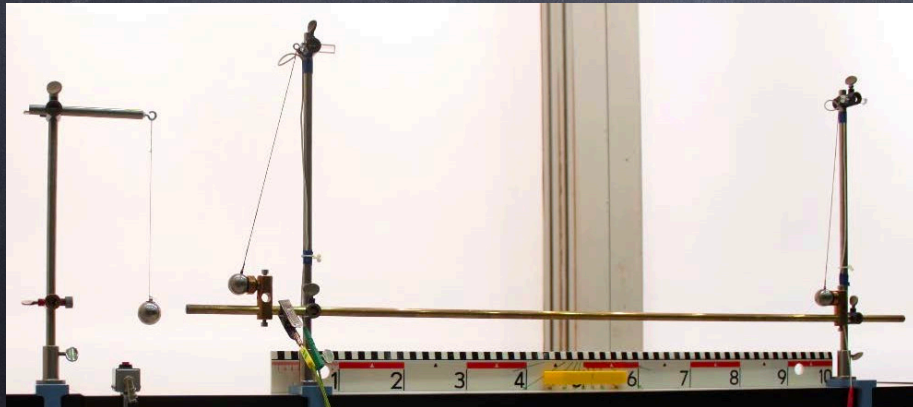
Derivation:

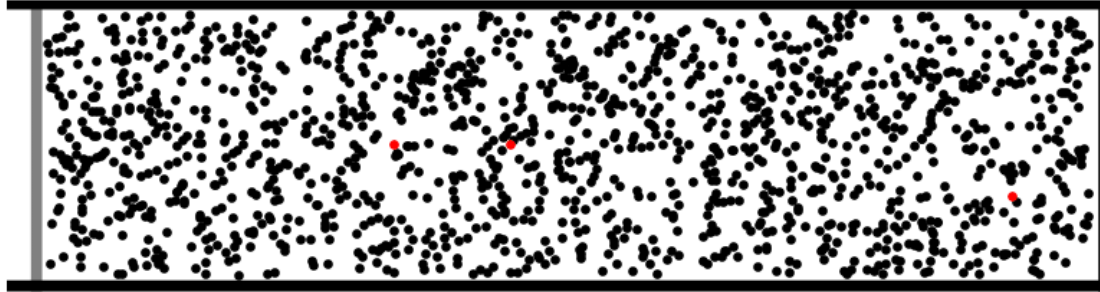




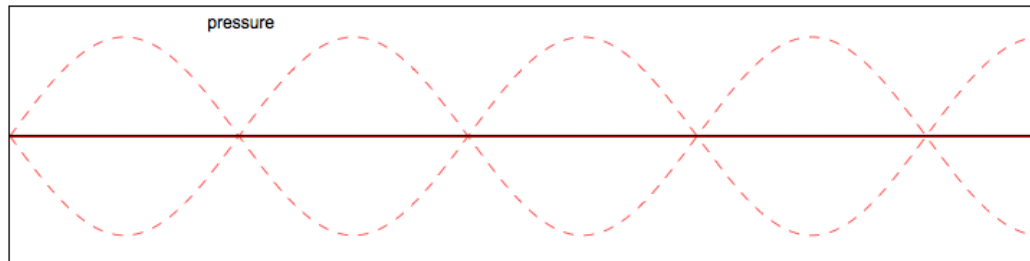
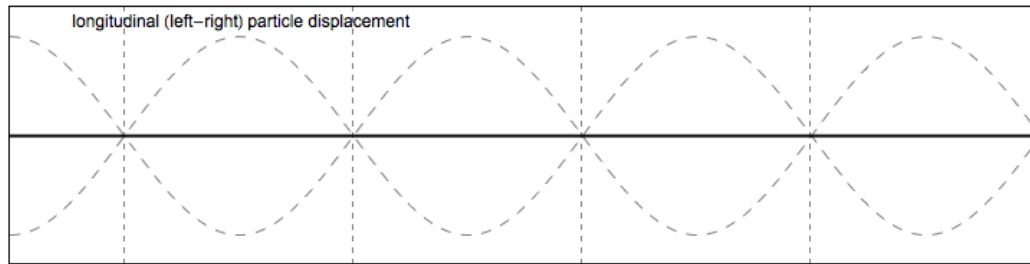


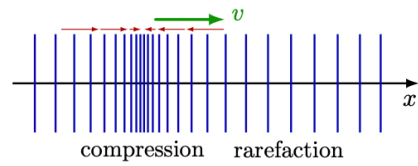




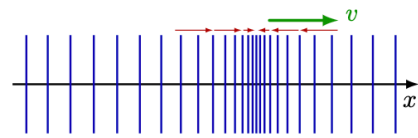


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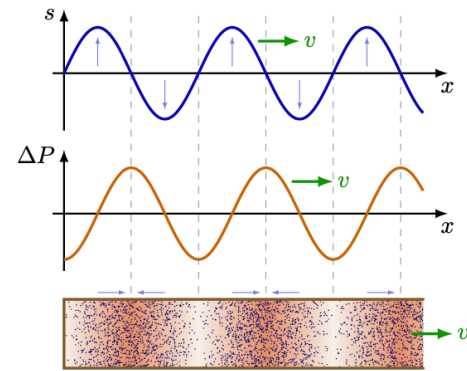


(a) Time  $t = 0$ .

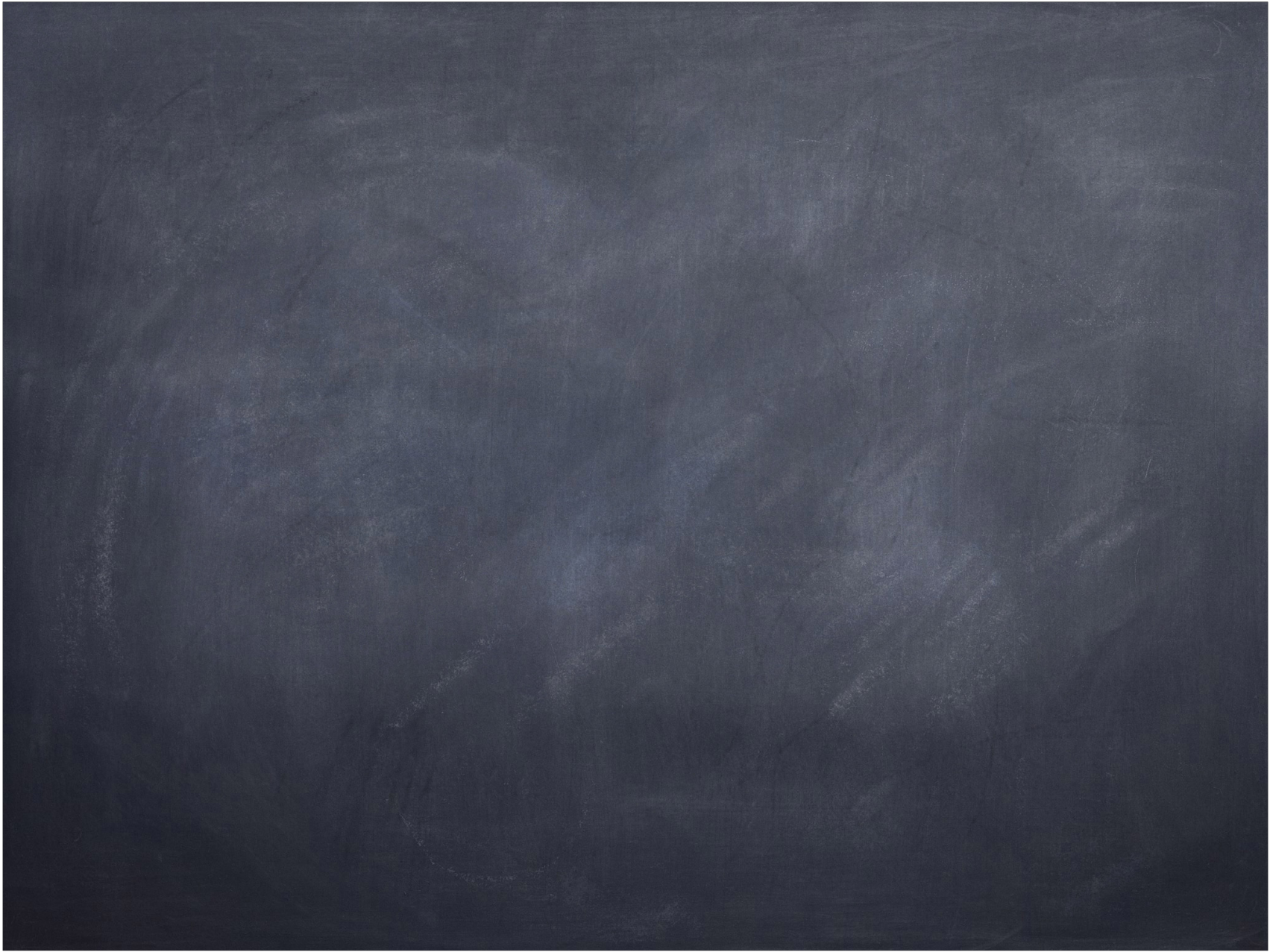


(b) Time  $t = \Delta t$ .

**Figure 13.10:** A traveling longitudinal wave is when the distortion happens along the direction of propagation, here shown as a local displacement.

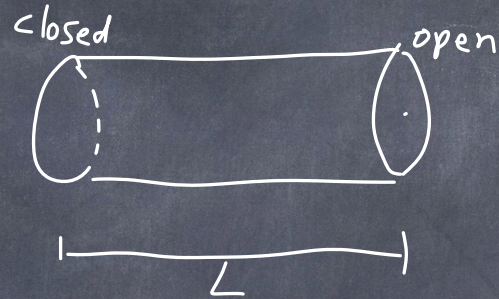


**Figure 13.11:** Sound wave traveling in a tube of air, shown as a local, average displacement  $s$  of air molecules in the longitudinal ( $x$ ) direction (blue), and a local pressure variation  $\Delta P$  (orange),  $90^\circ$  out of phase with  $s$ .



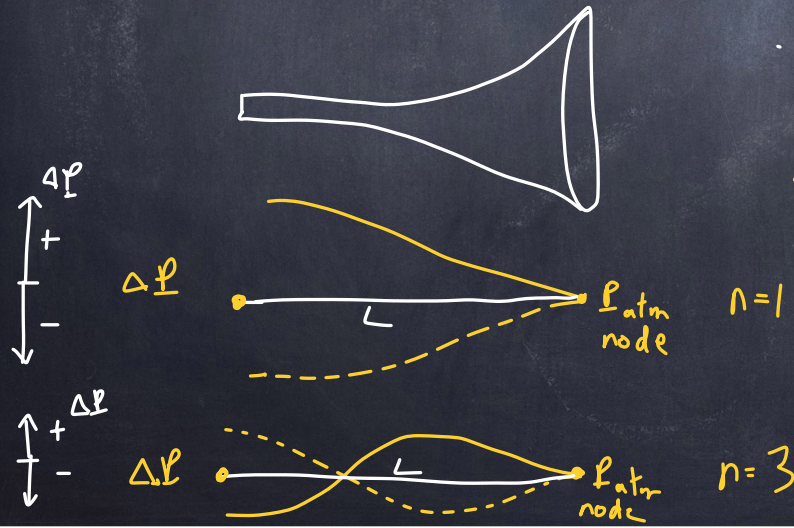
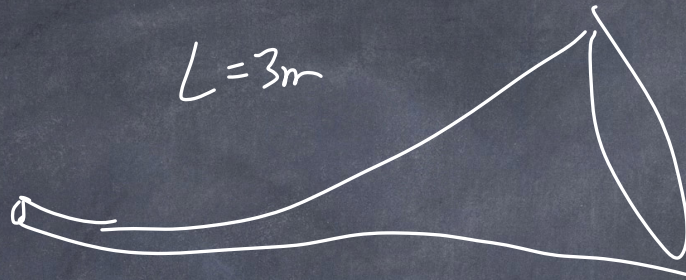


Standing waves in a tube closed on one end,  
open on the other end.

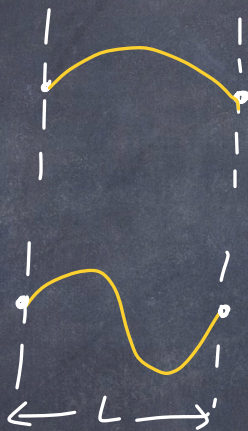
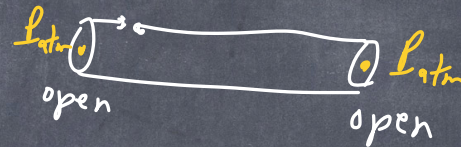


# Alphorn

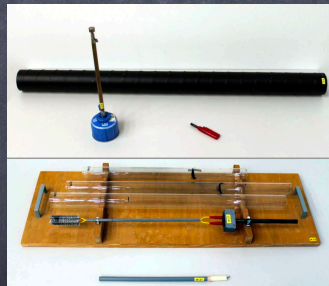
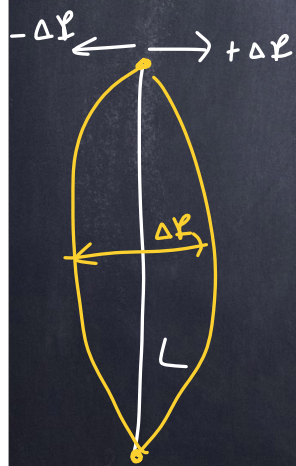
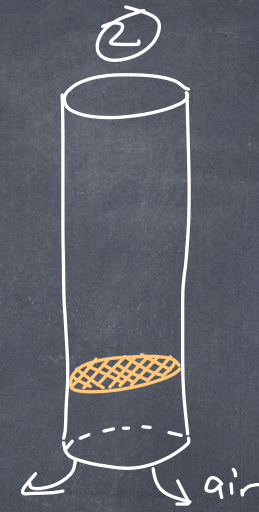
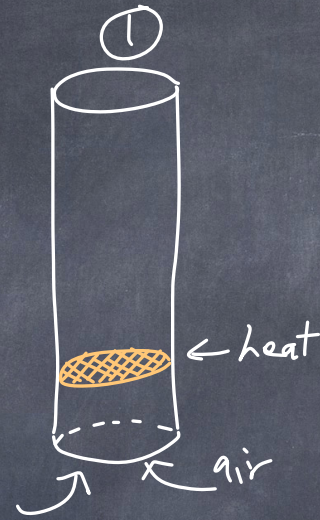
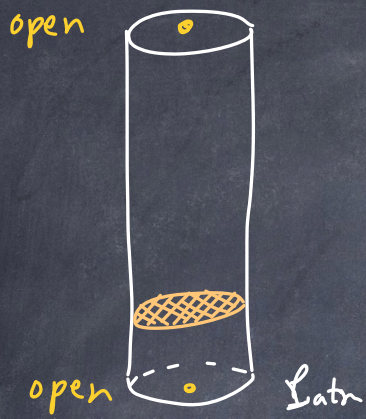
$$L = 3\text{m}$$

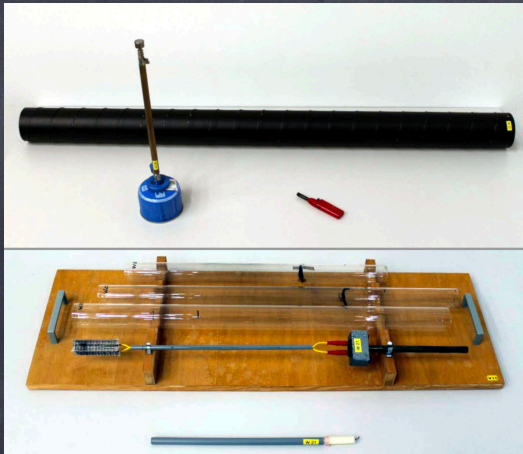


Standing sound waves, tube open on both ends  
(flute)



# Rijke tube - self-amplifying standing sound waves.

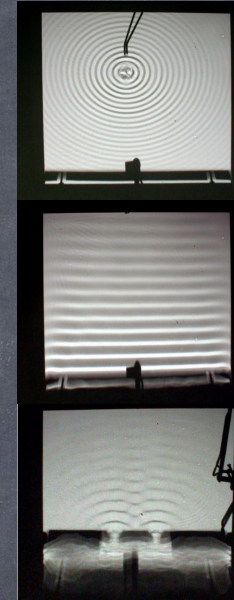




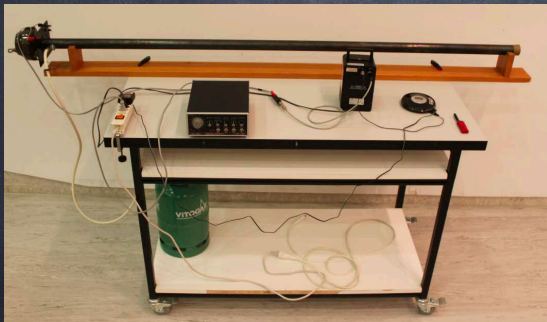
W21



W13



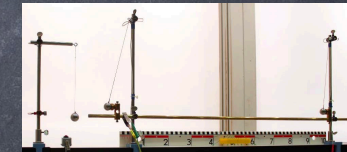
W108



W34



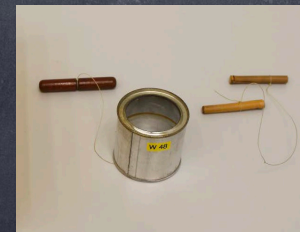
W110



W32



W36



W48



W33