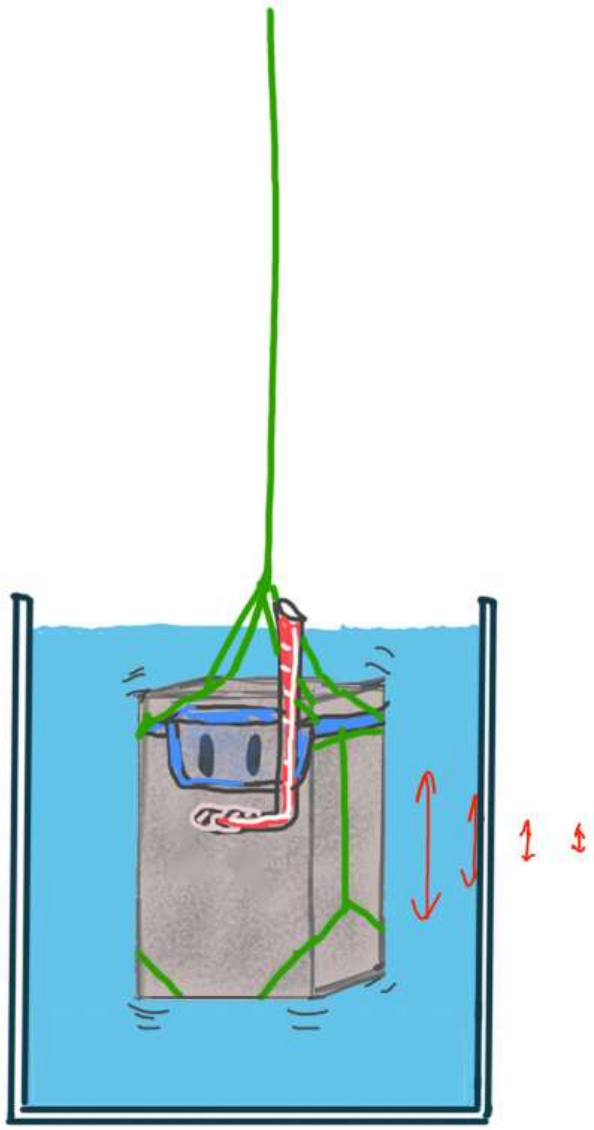
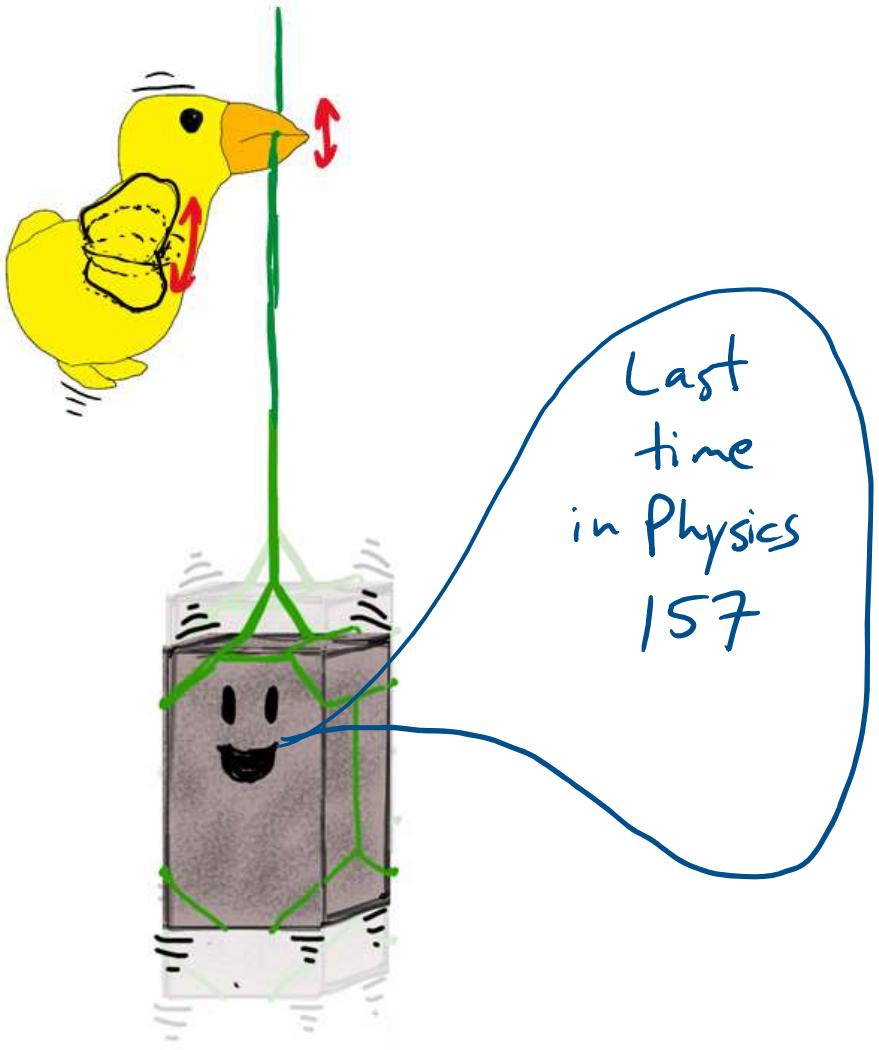
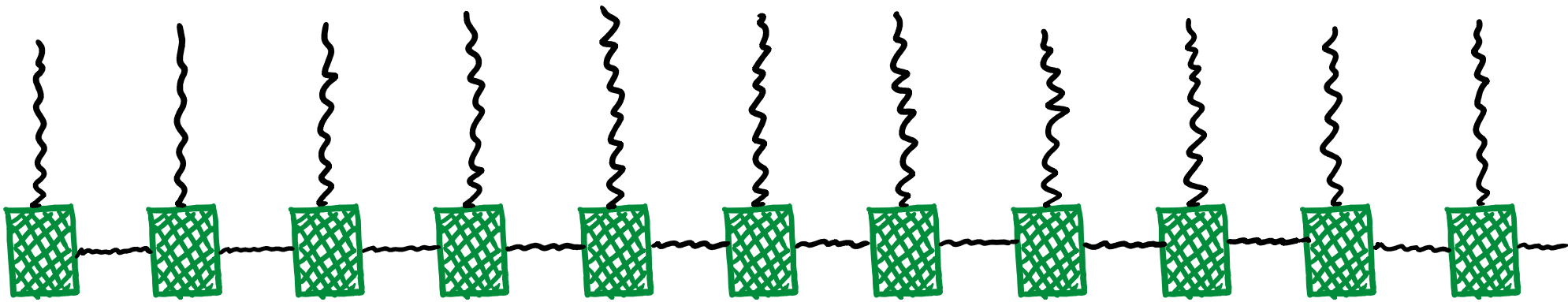
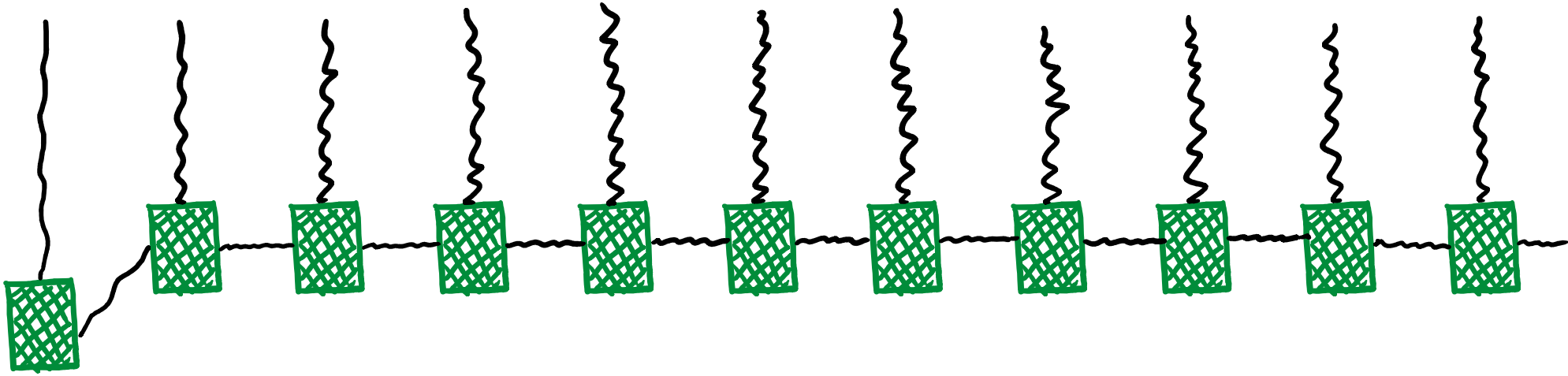



Last
time
in Physics
157

Coupled oscillators:

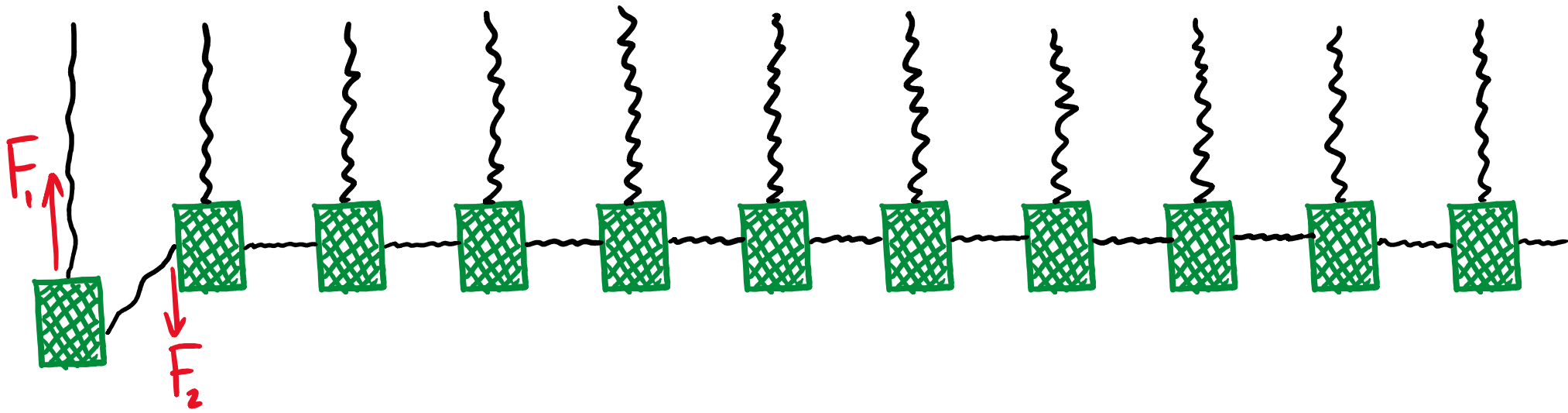


What happens if we pull the leftmost one down and release it?



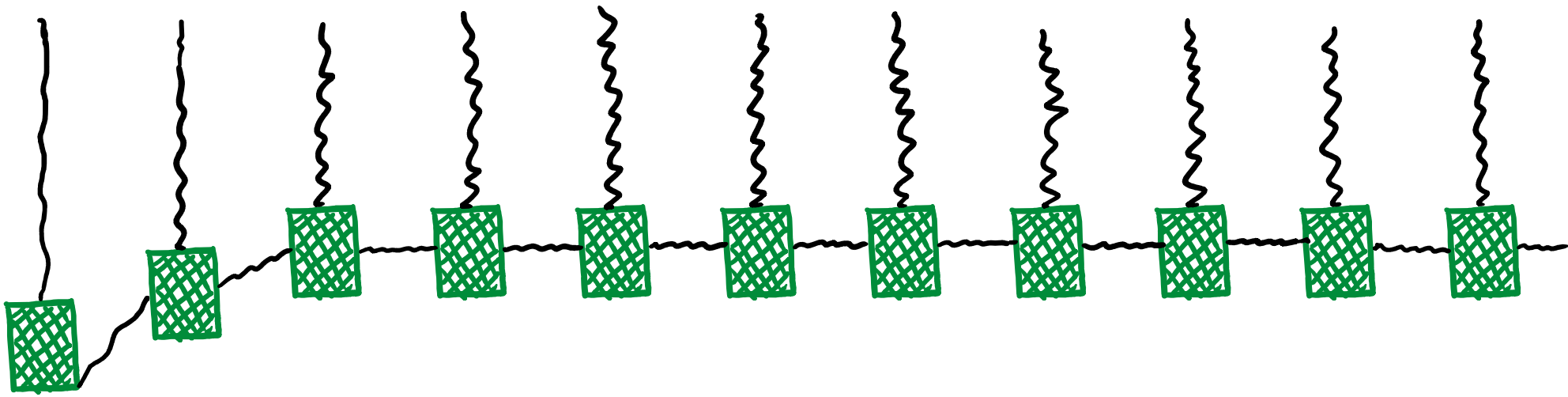
Coupled oscillators: Displacement of one oscillator leads to:

F_1 : restoring forces on that oscillator

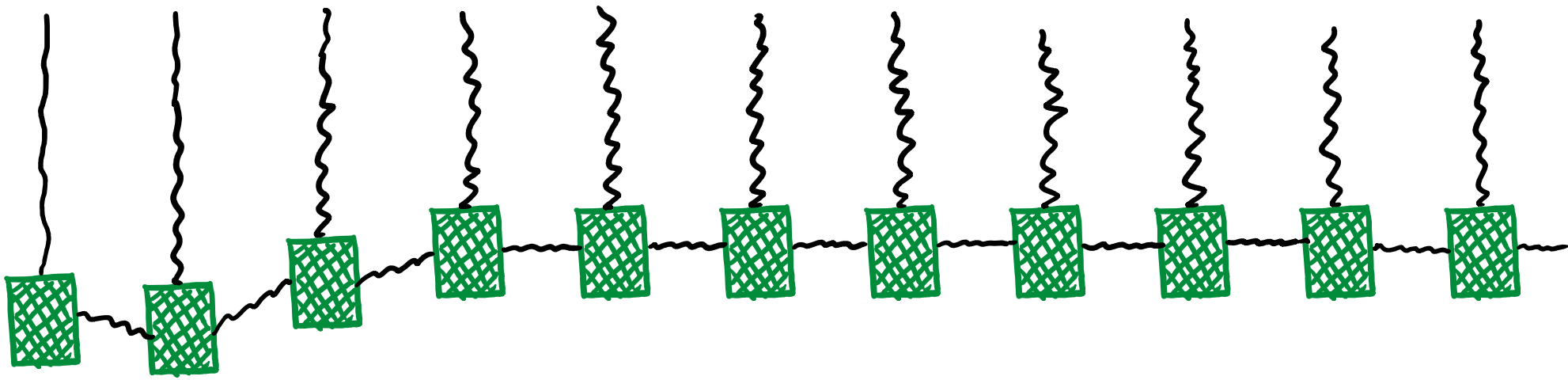


F_2 : forces to displace the nearby oscillators

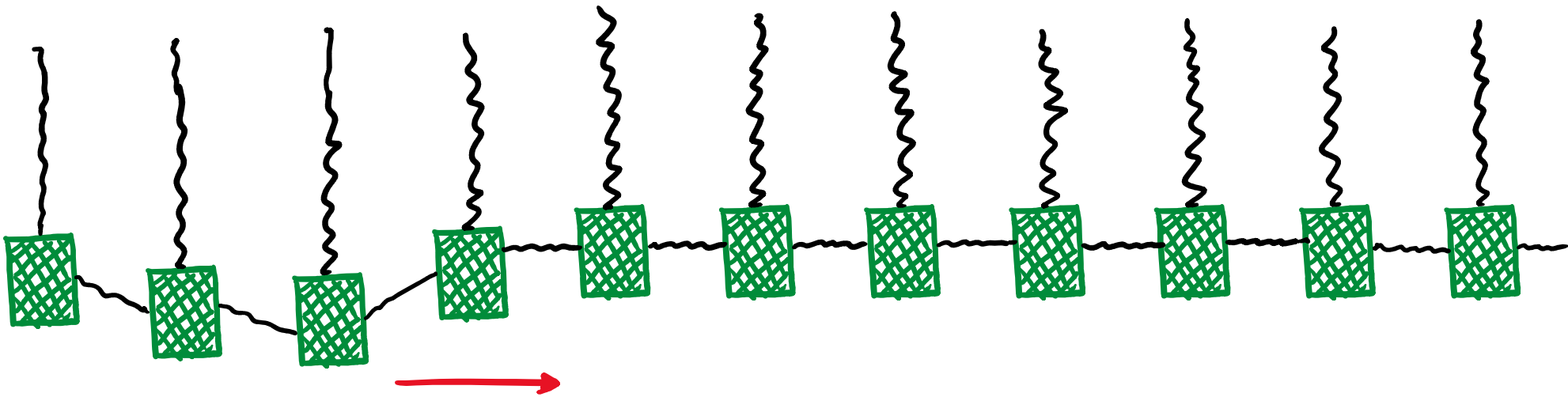
Coupled oscillators:



Coupled oscillators:

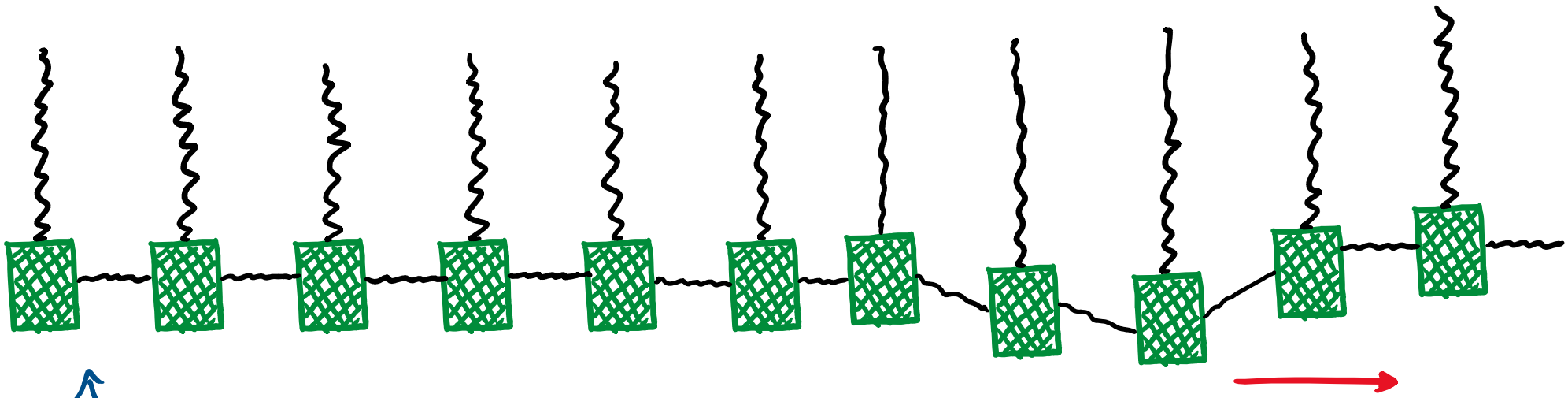


Coupled oscillators:



disturbance propagates along the chain

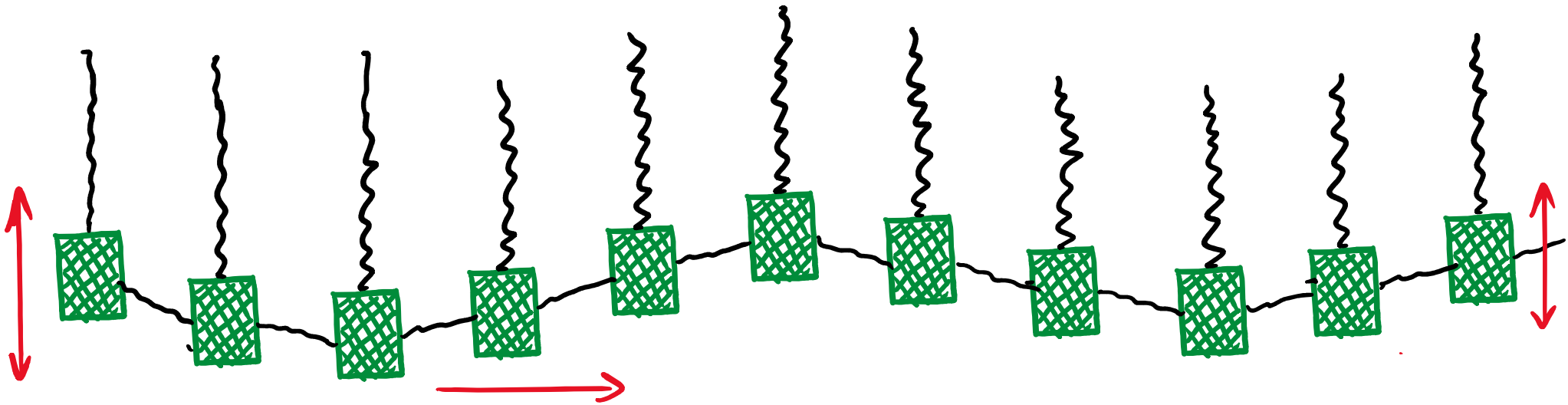
Coupled oscillators:



these ones settle down to equilibrium since energy is transferred to the other oscillators

Coupled oscillators:

if we drive the leftmost oscillator...

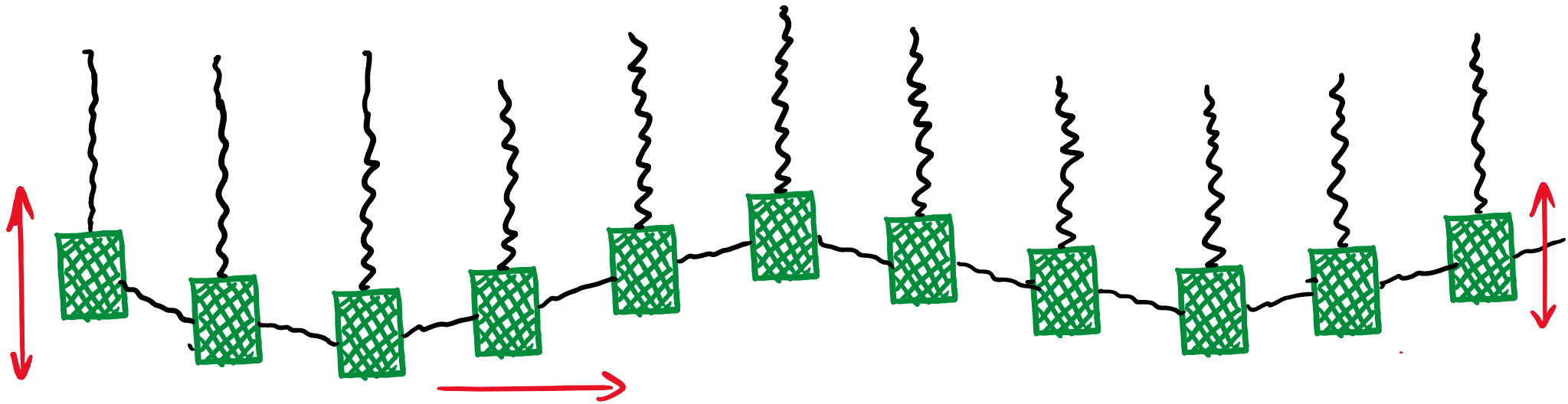


get traveling wave!

- continuously adding energy to system

Coupled oscillators:

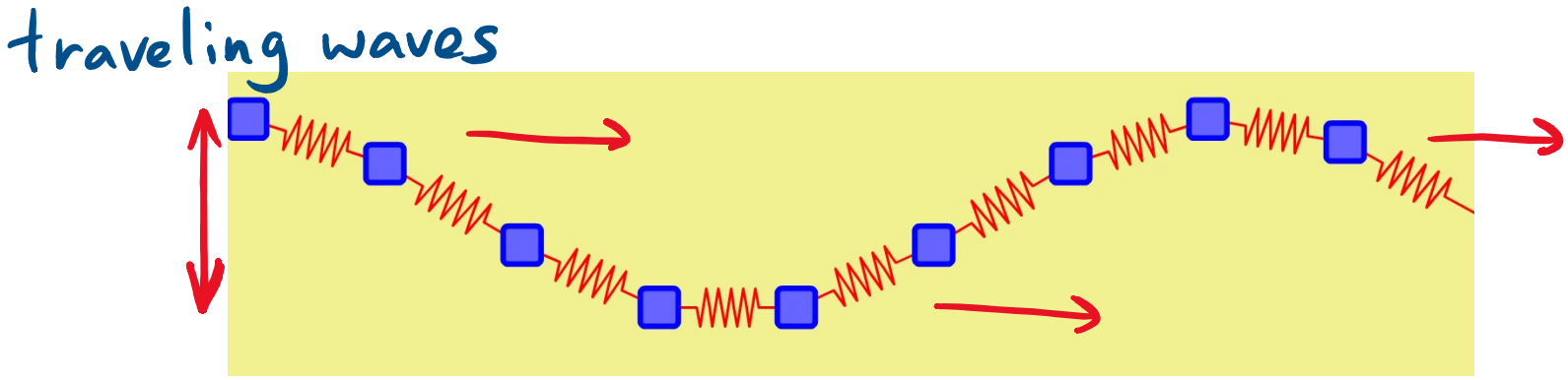
if we drive the leftmost oscillator...



get traveling wave!

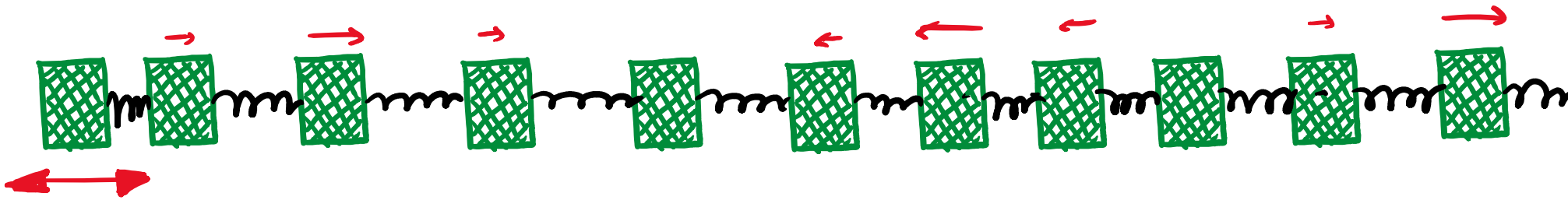
Transverse wave: oscillations perpendicular to direction wave travels

Coupled oscillator simulation: https://phet.colorado.edu/sims/normal-modes/normal-modes_en.html



Coupled oscillators: longitudinal displacement

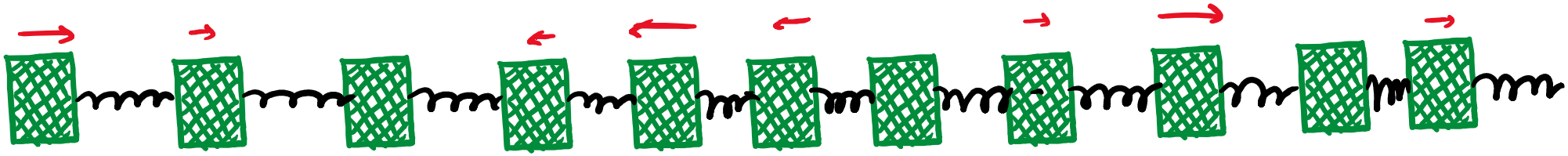
Coupled oscillators:



LONGITUDINAL WAVE

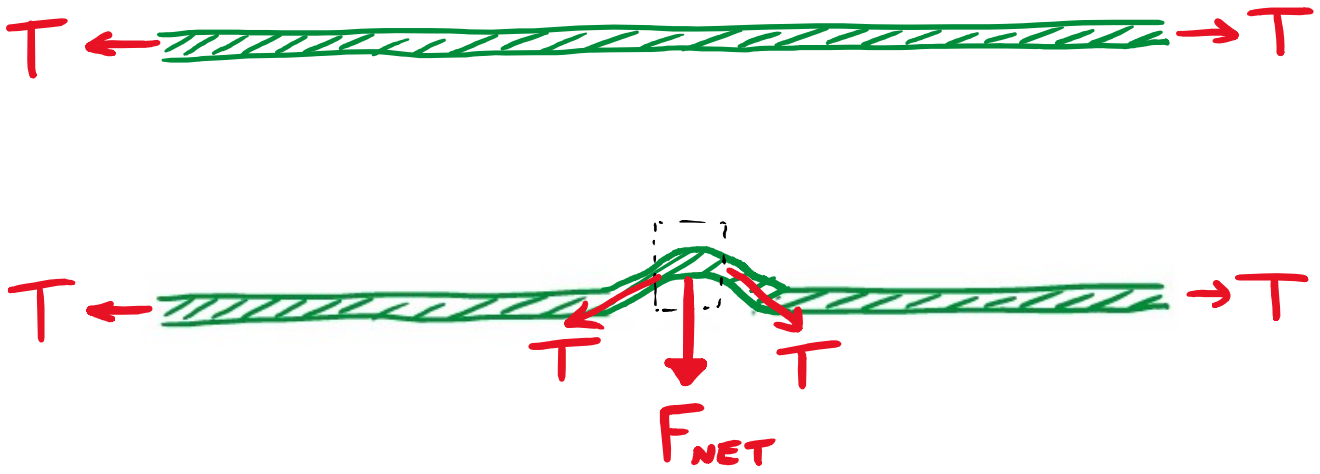
Coupled oscillators:

Coupled oscillators:

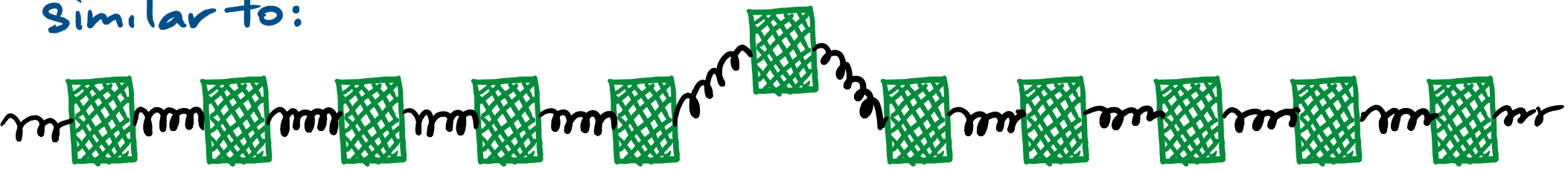


Many (most?) physical systems act as coupled oscillators...

Stretched string: tension provides restoring force for displaced section



similar to:

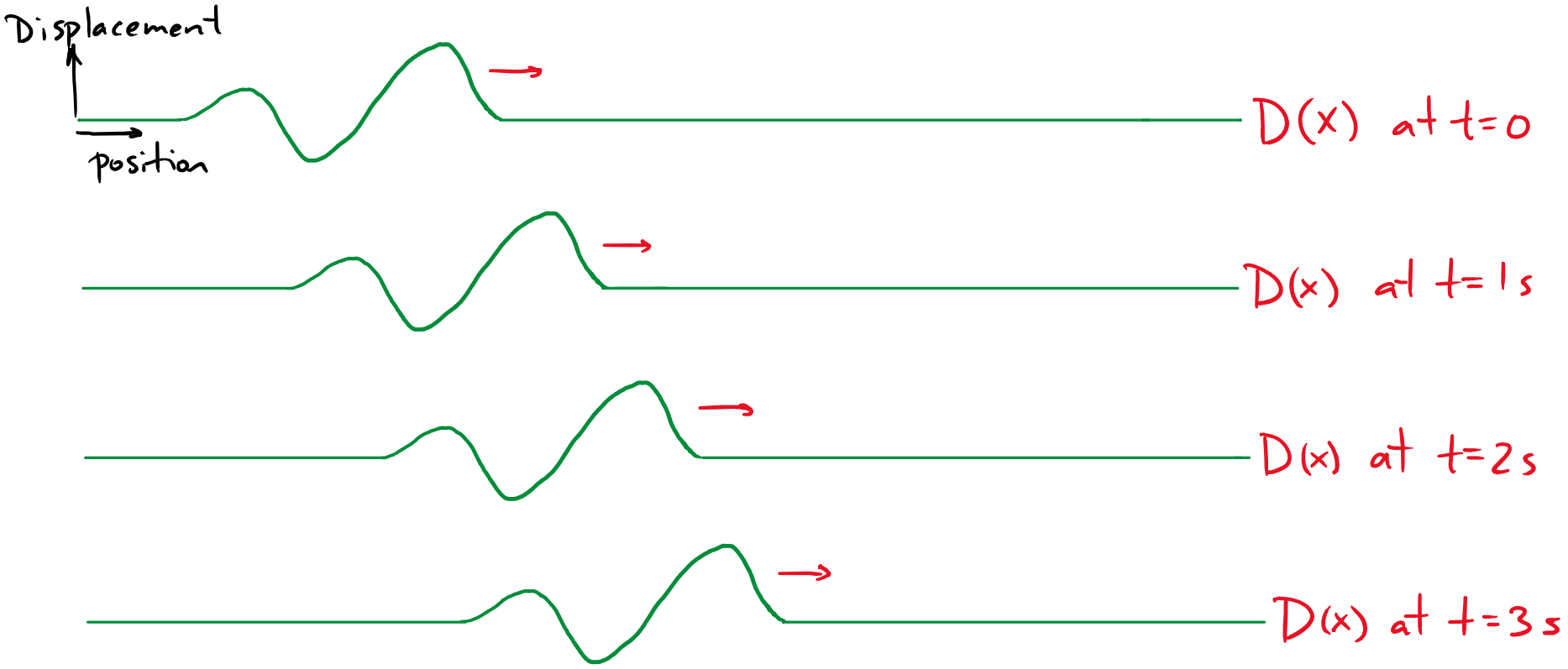


PHET Demo: waves on a string:

https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html

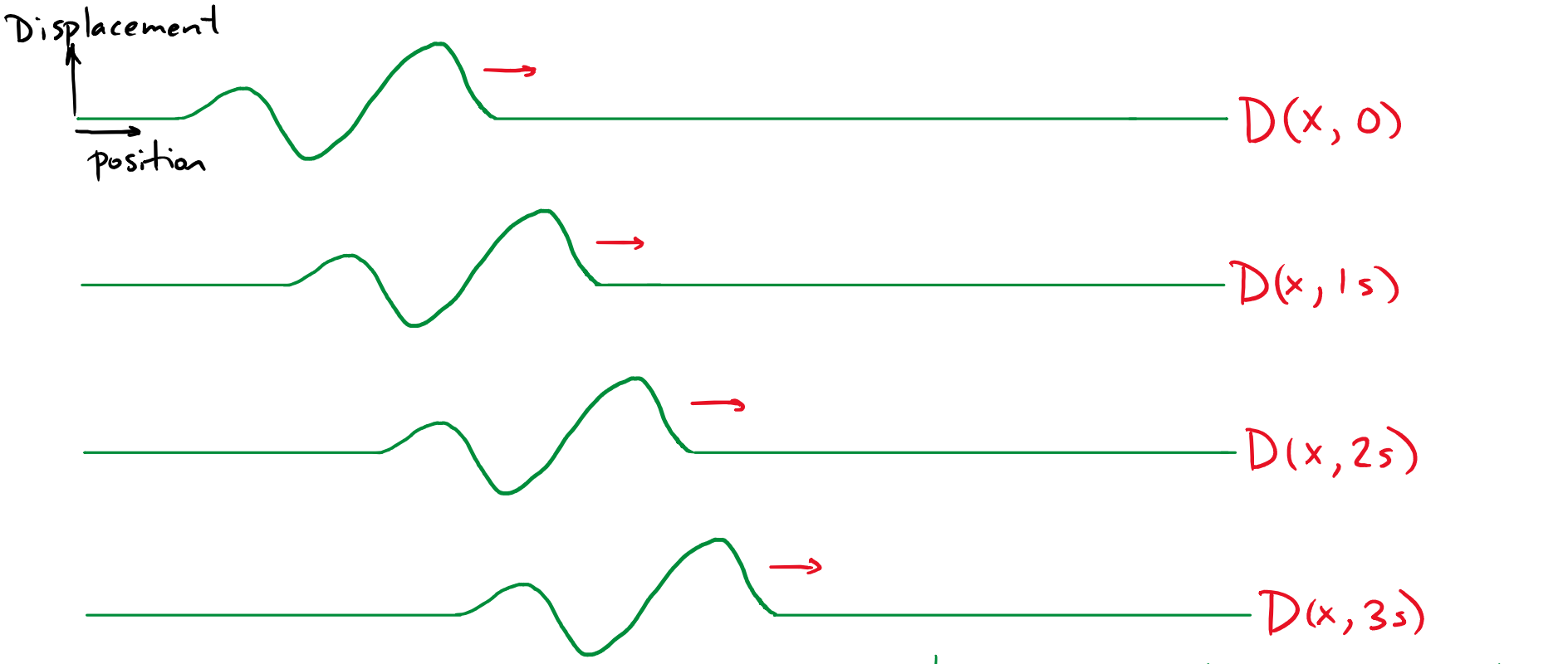
Mathematical description of waves:

At each time, we have a function that describes a "snapshot" of the wave at that time:



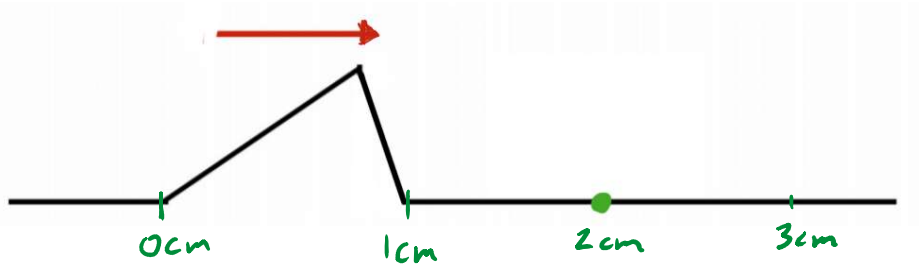
Mathematical description of waves:

define $D(x,t)$: displacement at position x at time t.

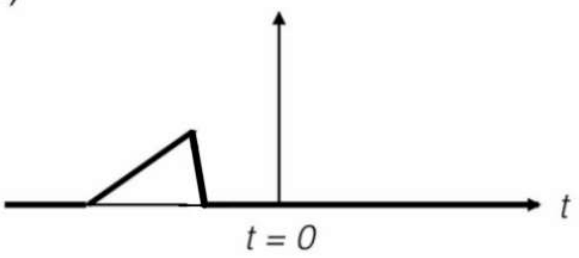


note: some waves change shape over time

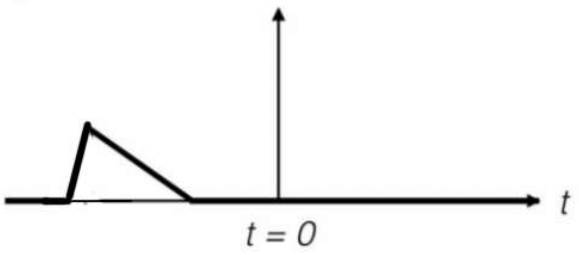
The graph to the right shows D(x, 0), the snapshot of a right-moving wave pulse at time t=0. Which of the graphs below could represent D(2cm,t)?



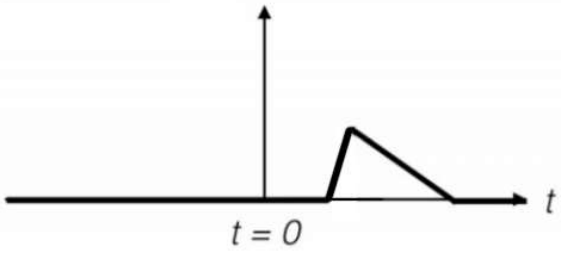
A)



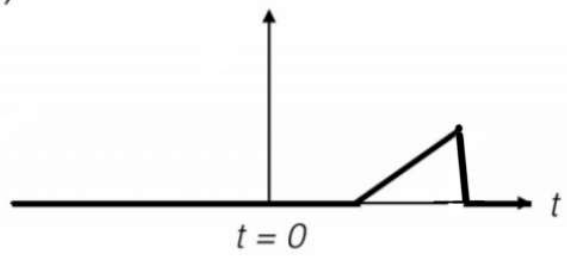
B)



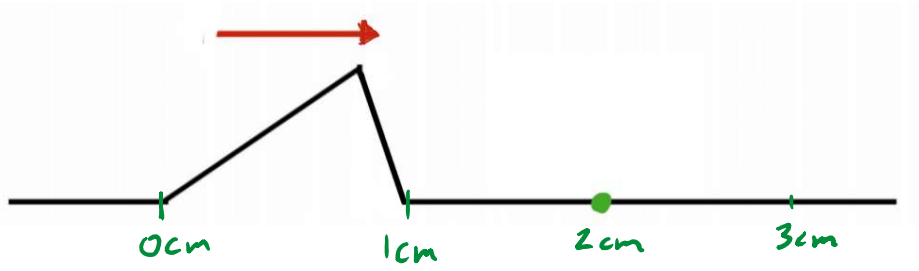
C)



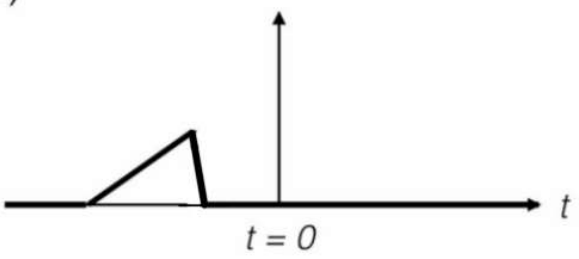
D)



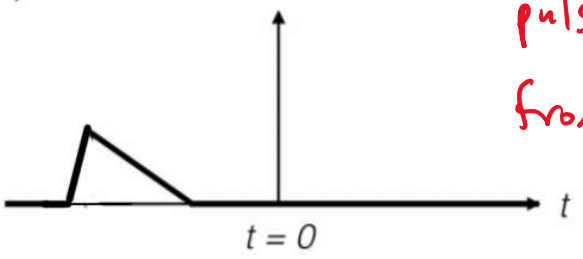
The graph to the right shows D(x, 0), the snapshot of a right-moving wave pulse at time t=0. Which of the graphs below could represent D(2cm,t)?



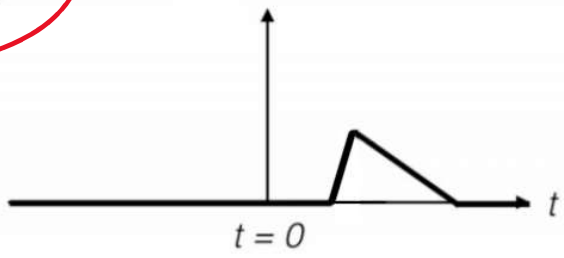
A)



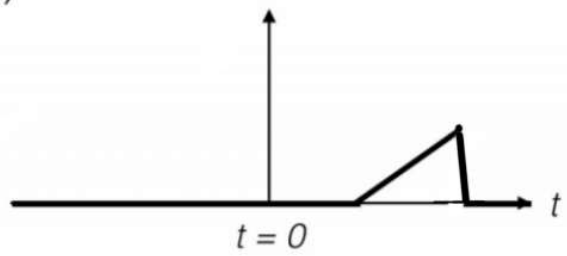
B)



C)



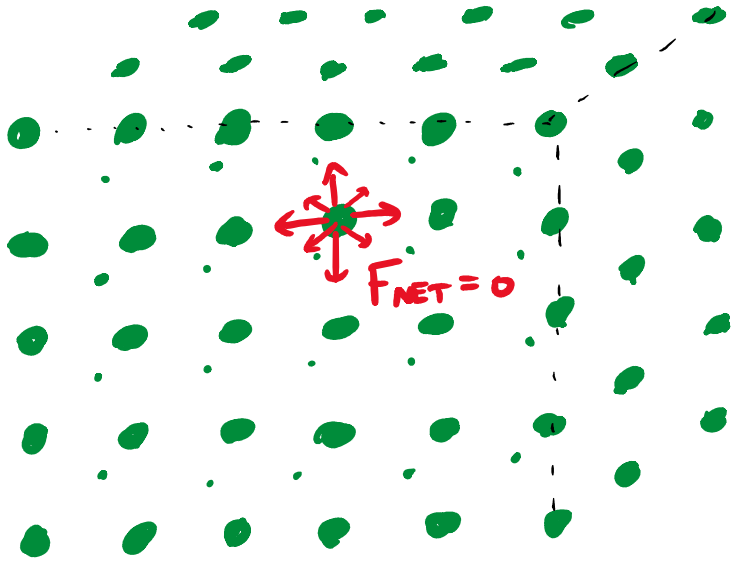
D)



no motion before t=0

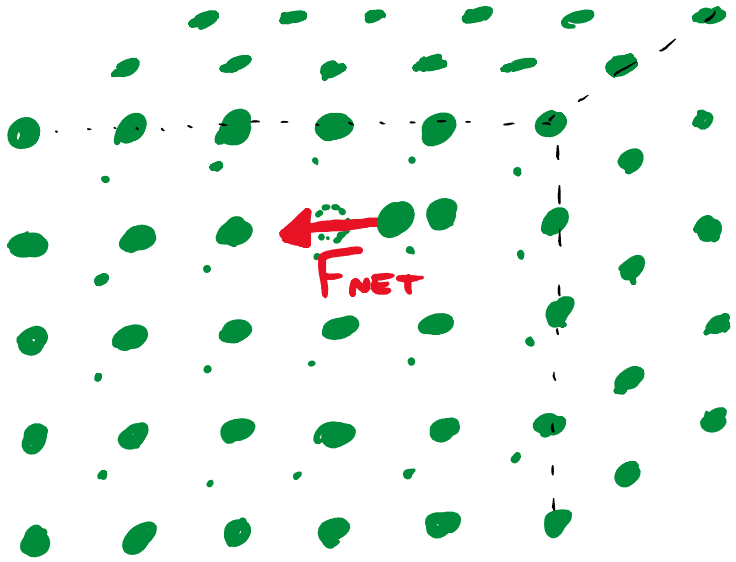
at some time after t=0 pulse reaches green dot, front of pulse is steeper, so displacement increases quickly then decreases slowly.

Solid: each atom is in an equilibrium position



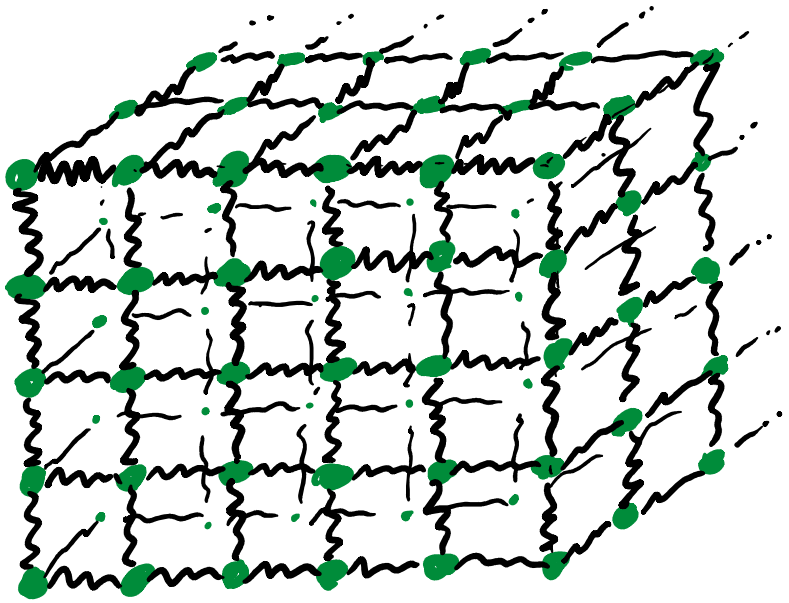
Solid: each atom is in an equilibrium position

- displaced atoms feel restoring force

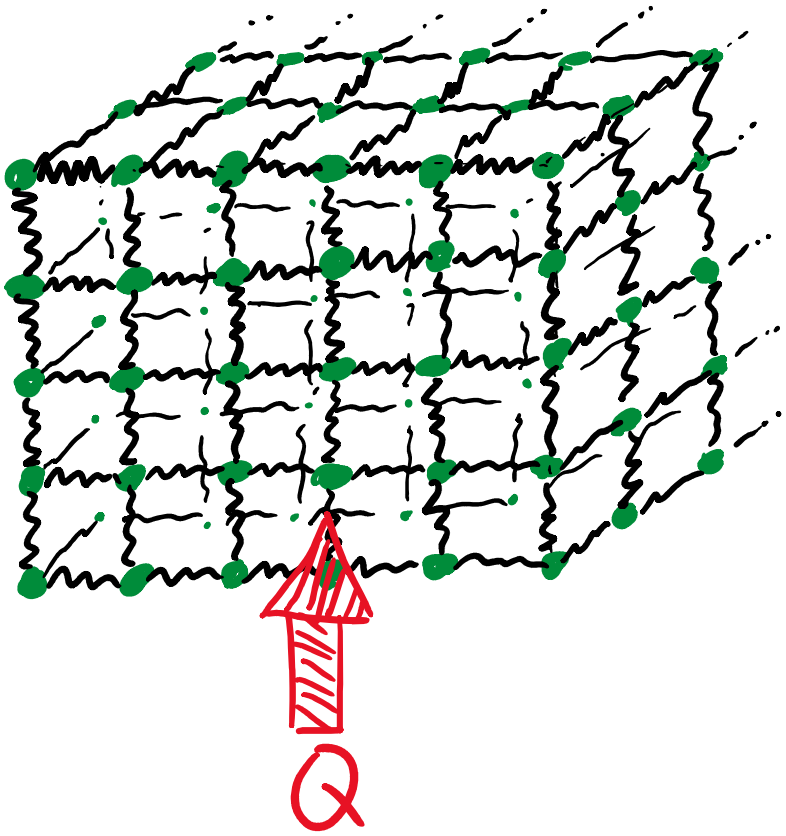


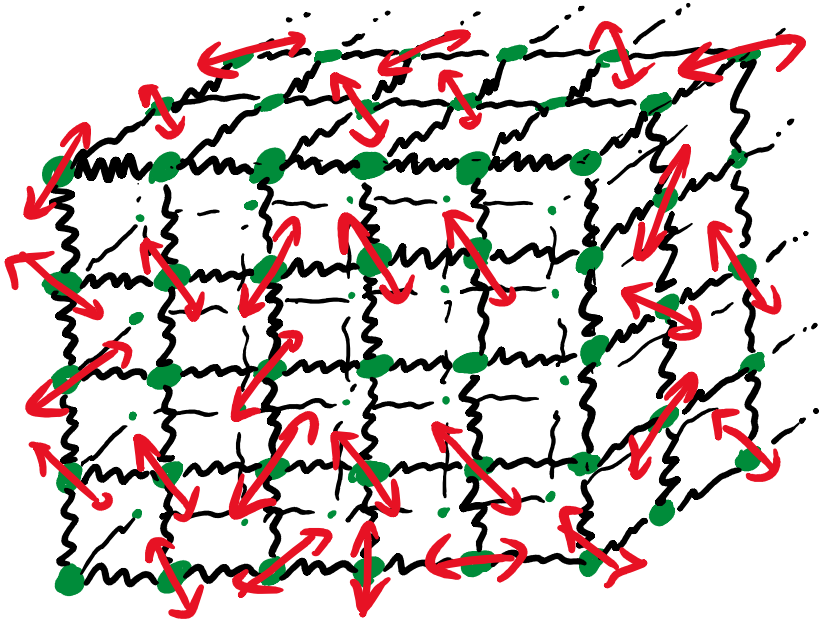
Solid: each atom is in an equilibrium position

Similar to a lot of coupled oscillators:

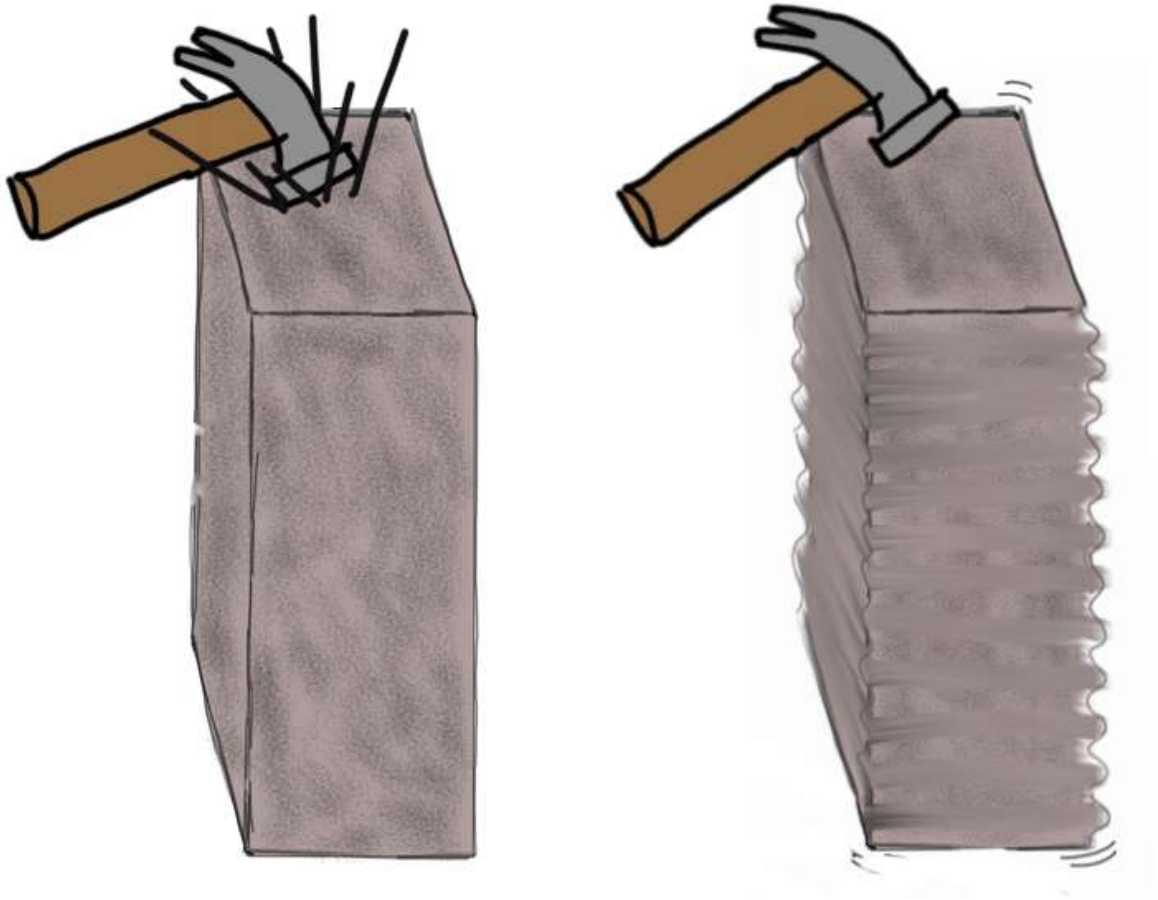


Warm solid: these oscillators have small random oscillations about equilibrium

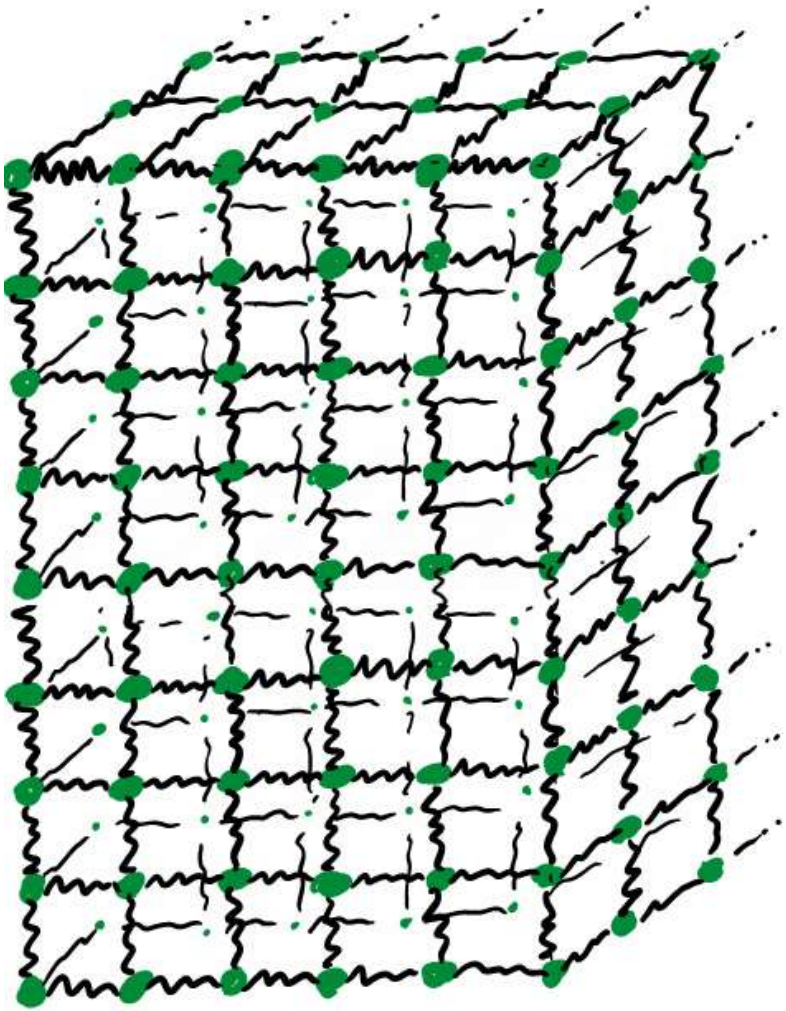




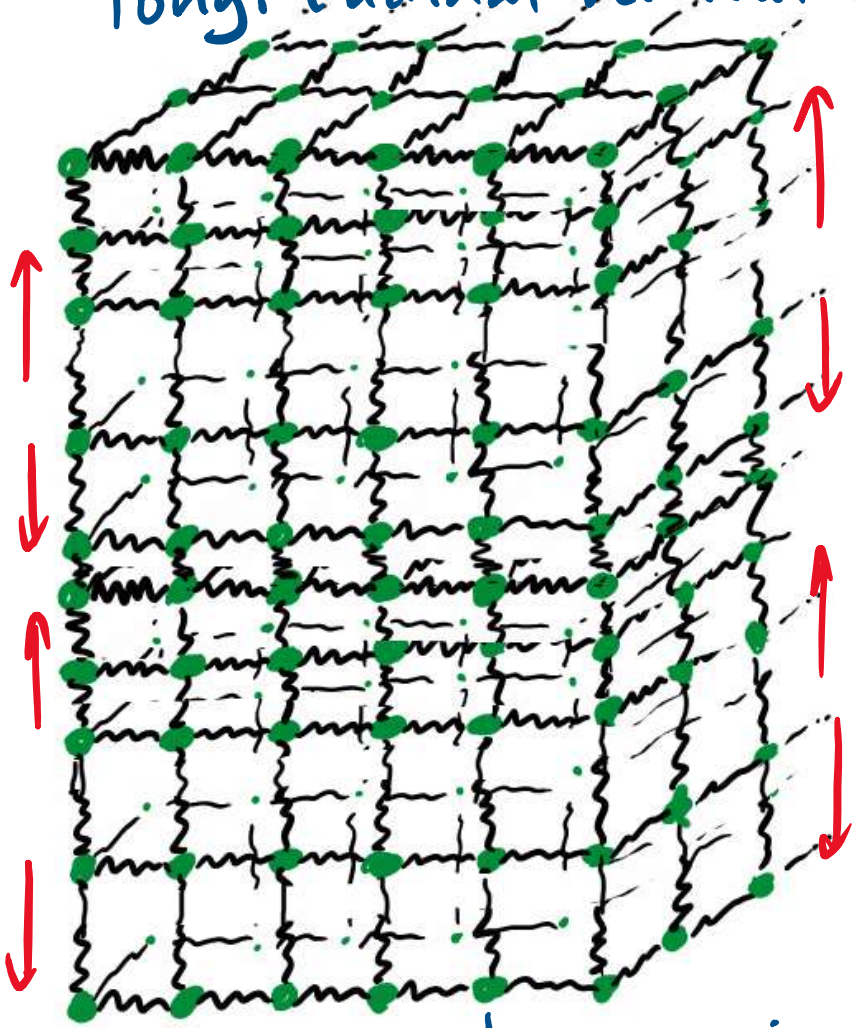
But: can also have coordinated oscillations
due to macroscopic external forces



equilibrium:

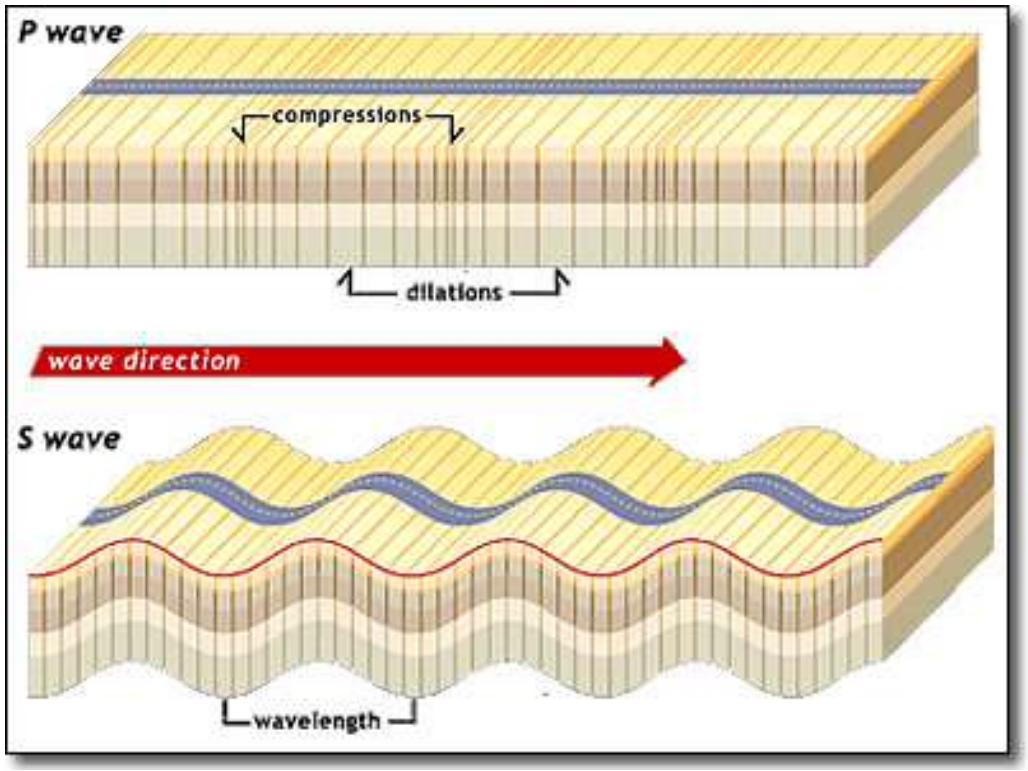


longitudinal vertical wave



= sound wave in solid.

Can also have transverse waves in solids: e.g. S waves in earthquakes



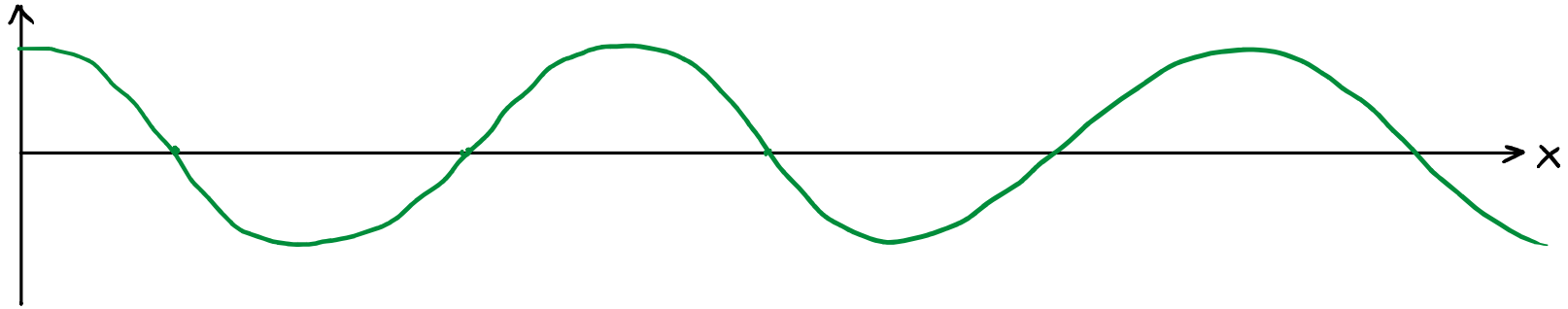
longitudinal
faster "primary"

transverse
slower "secondary"

also: surface waves

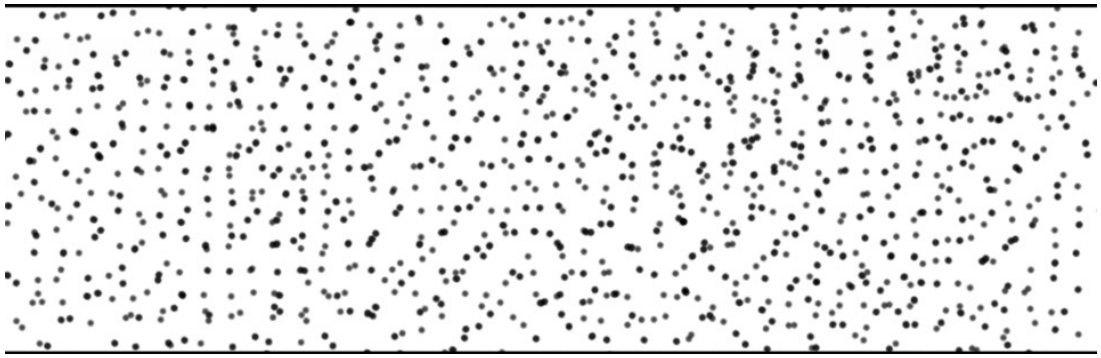
from www.sms-tsunami-warning.com

Discussion question:

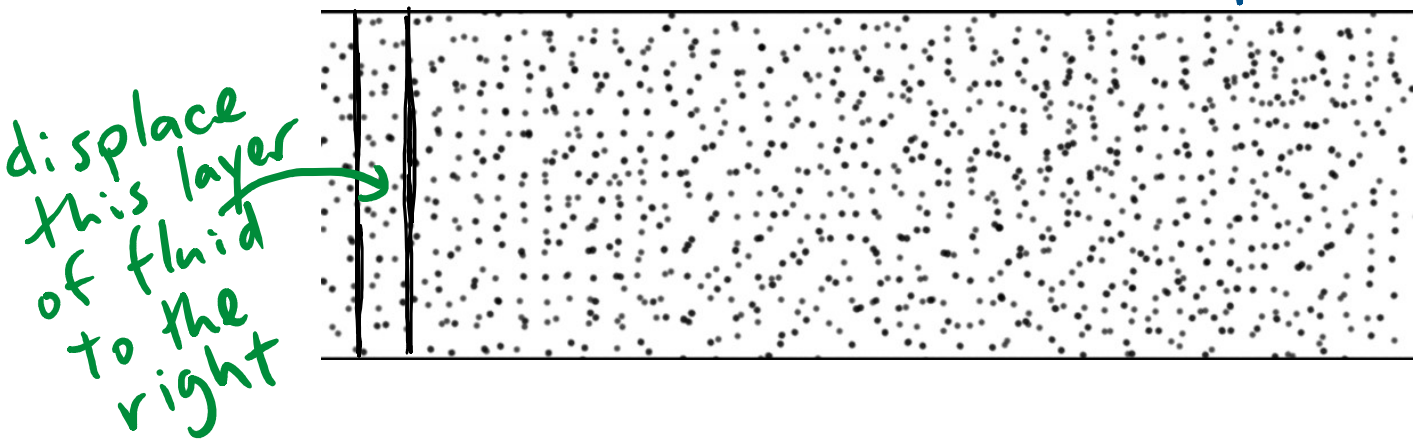


What is "waving" in a sound wave? What does the vertical axis represent if this describes a sound wave at some time?

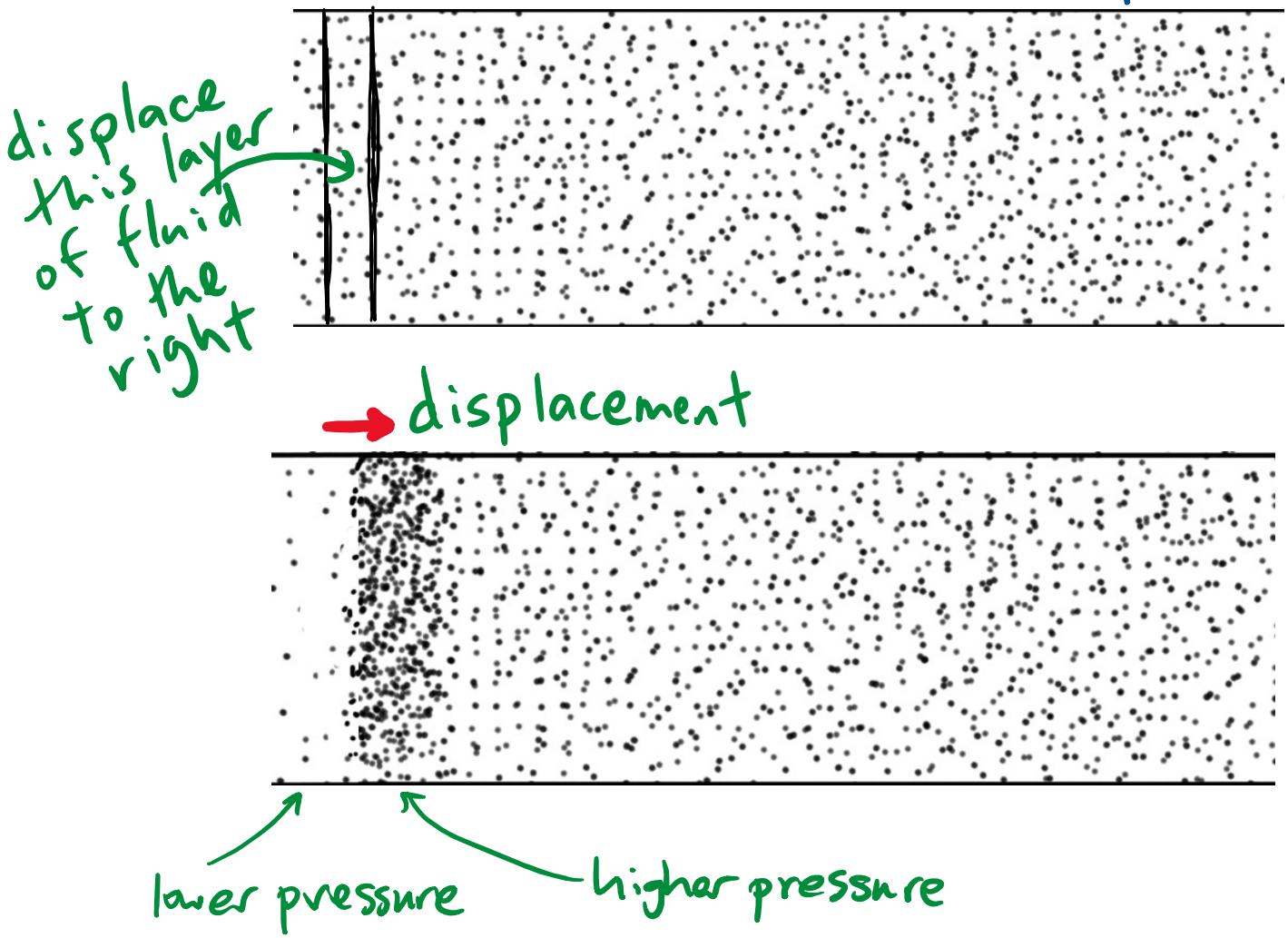
Fluid in equilibrium: uniform density/pressure



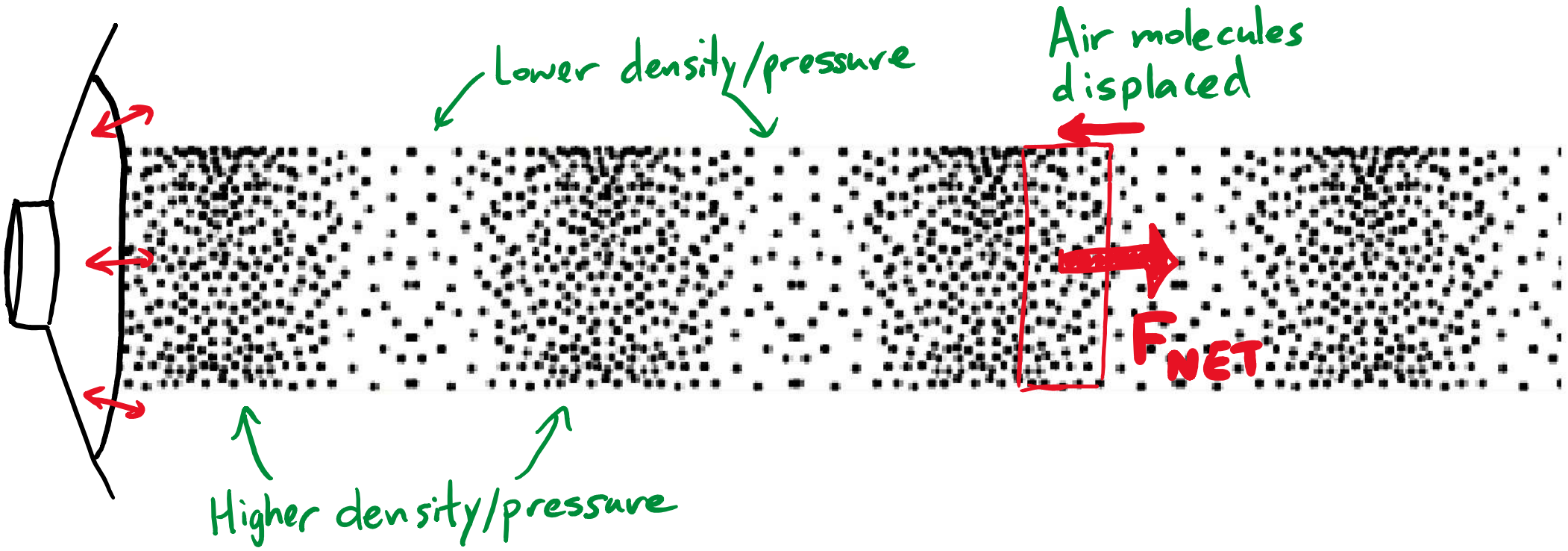
Fluid in equilibrium: uniform density/pressure



Fluid in equilibrium: uniform density/pressure



Sound in a fluid: longitudinal waves



https://www.youtube.com/watch?v=px3oVGXr4mo&t=1m46s