Announcement

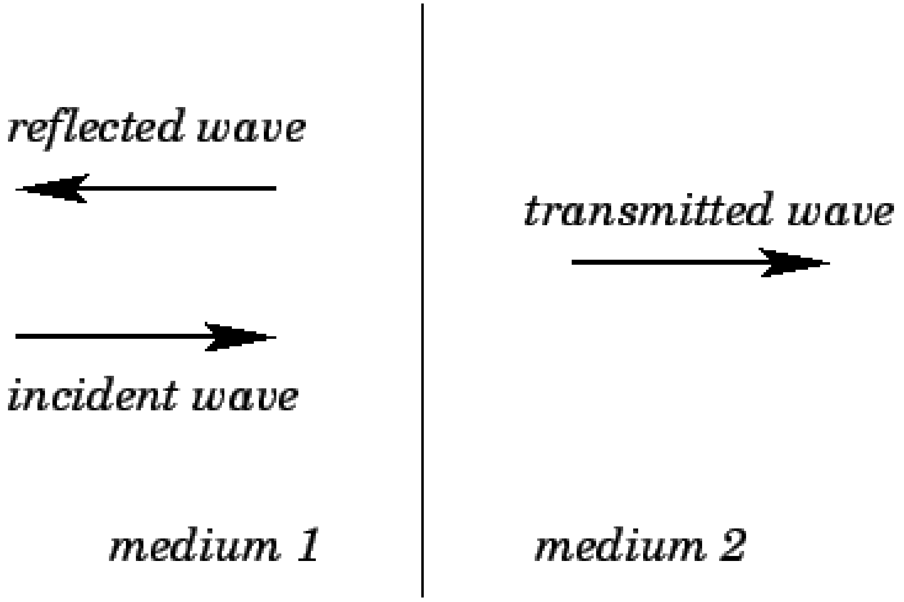
- Homework 5 is due March 1, next Wednesday.
- Get your solutions to exam 1 **in class** or **Dr. Guan's office hour** before Friday's class, Feb 24. Otherwise we will return your exam 1 at exam 2.
- Re-grade request has to be initiated with Dr. Guan in person or over zoom. We do not process canvas requests for regrade.

Today’s class

- Peer teaching evaluation
- Exam 1 review
- Waves
- Confining a particle

Review of classical waves

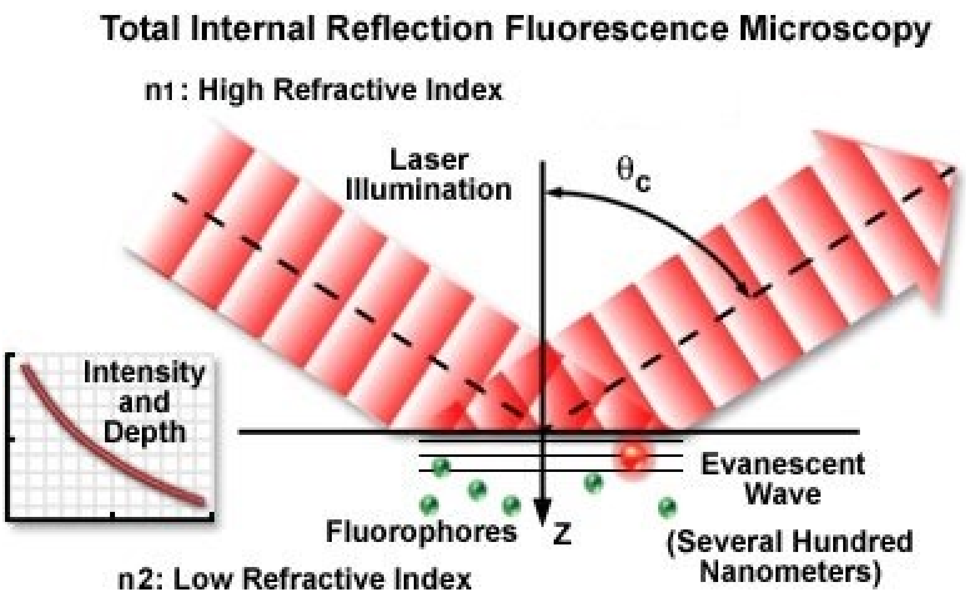
When a wave crosses a boundary between two regions, part of the wave intensity is reflected and part is transmitted.



Review of classical waves

When a wave encounters a boundary to a region from which it is forbidden, the wave will penetrate perhaps by a few wavelengths before reflecting.

oil

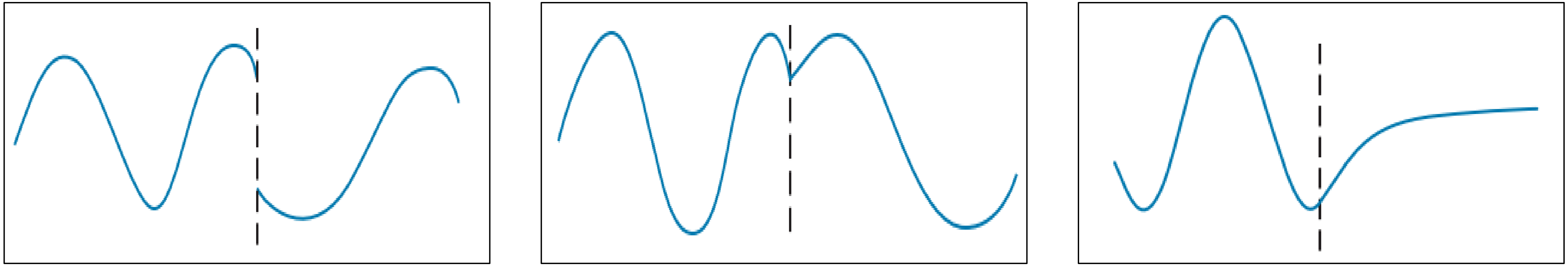


Water

Review of classical waves

At a finite boundary, the wave and its slope are continuous.
At an infinite boundary, the wave is continuous but its slope is discontinuous.

Which one is allowed?



not allowed

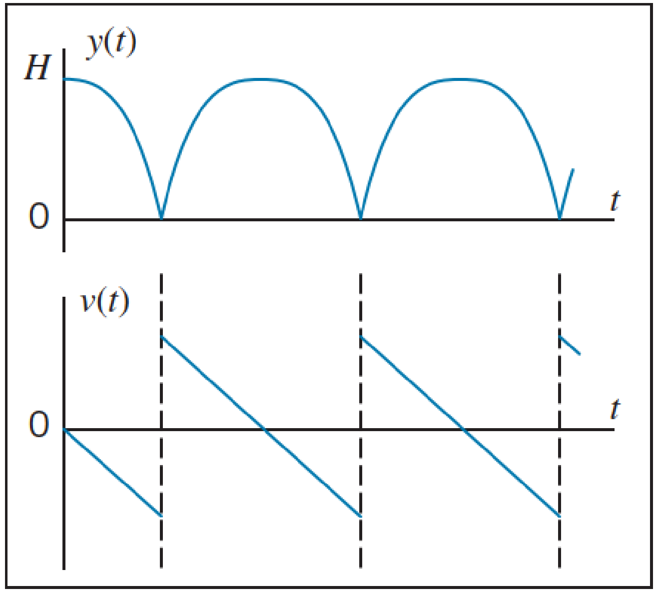
maybe
∞ boundary

✓

Wave function

Definition: the mathematical function that describes the wave.

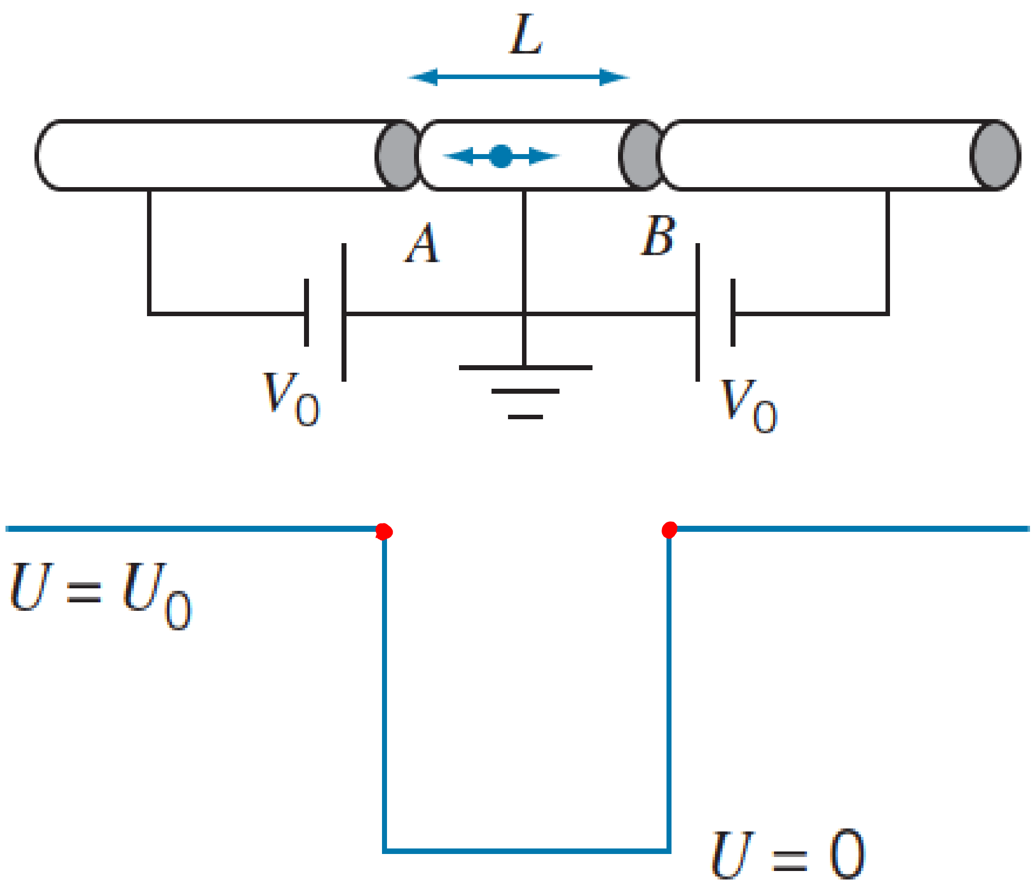
1. The wave function must be continuous.
2. The slope of the wave function must be continuous, except when the boundary height is infinite.



A trick to help you remember:
Think of a ball bouncing off the ground.

Wave function y(t) – continuous
Slope, derivative v(t) - discontinuous

Confining a particle



The setup confines an electron to inside the well.

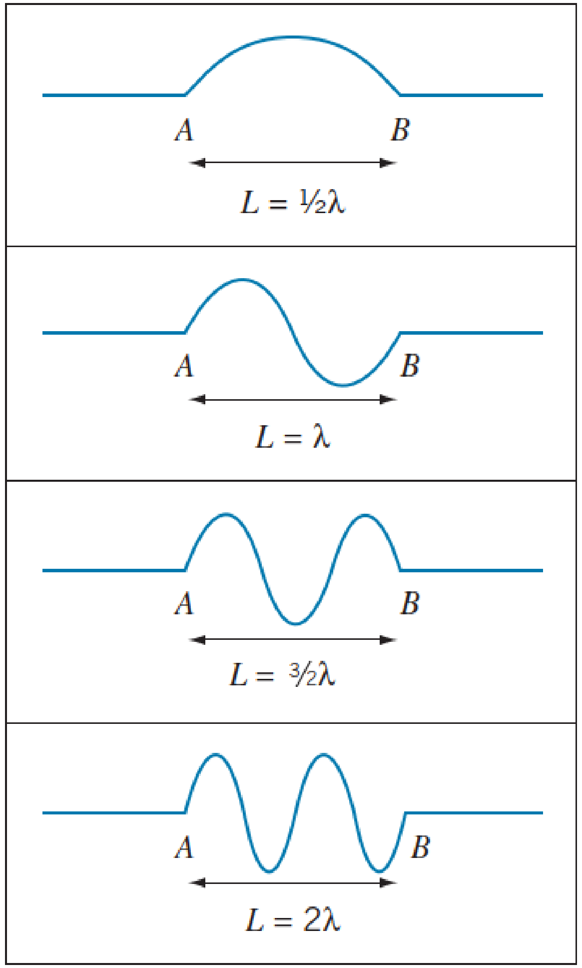
Boundary condition:

Continuous $\longrightarrow$ the wave function must have values of 0 at A and B

In-class exercise (5 min)

$L = n \cdot \frac{\lambda}{2}$

λ



(1) What are the wavelengths allowed?
Hint: express in L and n=1,2,3

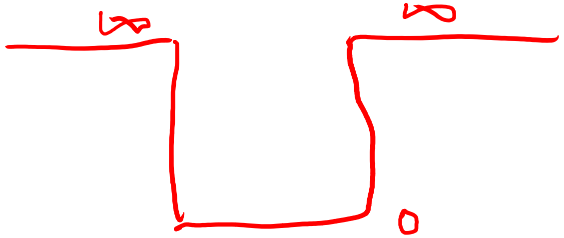
$\lambda_n = \frac{2L}{n}$ $n = 1, 2, 3 \ldots\ldots$

(2) From de Broglie relationship, what are the momentums allowed?

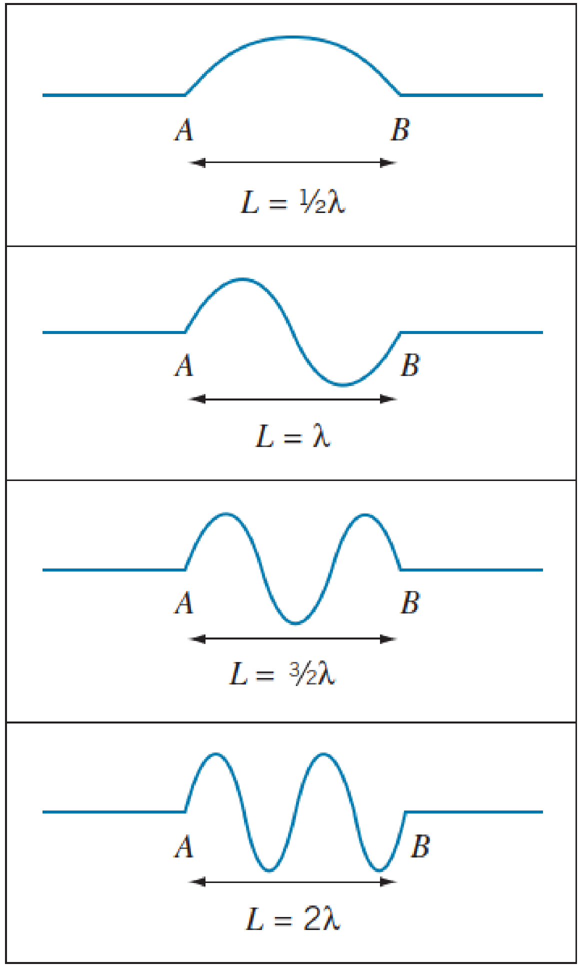
$p_n = n \cdot \frac{h}{2L}$ $\left(\lambda = \frac{h}{p}\right)$

(3) What are the energies allowed?
Hint: only kinetic energy. Can calculate from momentum.

$E_n = \frac{n^2 h^2}{8 m L^2}$ $\left(E = \frac{p^2}{2m}\right)$



Slope is discontinuous – allowed under what condition?



The appearance of energy quantization accompanies every attempt to confine a particle to a finite region of space.

Going beyond the intuitive description shown here,
we will work out the rigorous way to describe this later.
"Particle-in-a-box"

Checking the uncertainty principle

$\Delta x \sim L$

$\Delta p_x = \sqrt{(p_x^2)_{av} - (p_{x,av})^2}$ $\qquad p_{x,av} = 0$

$p_x = \frac{nh}{2L}$

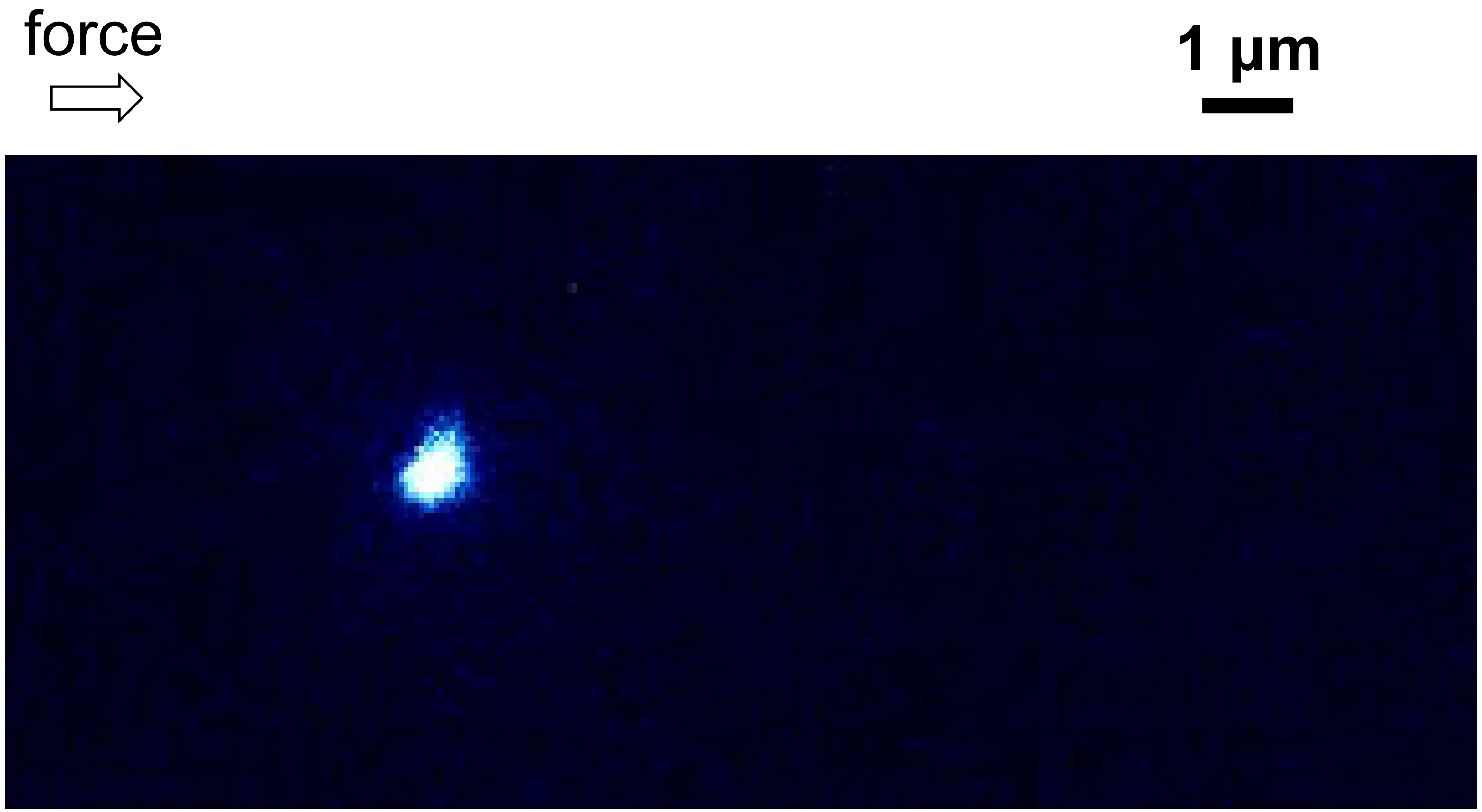
$\Delta p_x = \sqrt{(p_x)^2_{av}} = \frac{nh}{2L}$

$\Delta x \cdot \Delta p_x = L \cdot \frac{nh}{2L} = \frac{n}{2} h$ $\qquad n = 1, 2, 3, \ldots$

$\frac{n}{2} h \geq \frac{h}{2} > \frac{\hbar}{2}$

Q.E.D.

An application of quantum mechanics in my lab



DNA chain – fluorescence labeling
agarose gel network – invisible
played at real time