Lecture 7
Traveling Waves (I)

- **particles** (localized, individual, discrete) and **wave** (collective, continuous): two fundamental models of physics

- This week: (single) **traveling** waves (go outward from source thru’ medium), e.g. ripples on water, wave on a string, sound, light...(theory applicable to all waves)

- Next week: **standing** waves from **combining** traveling waves (interference)

- Next **course** (Phys 270): light
Outline:

• Types of waves

• Graphs

• Displacement function
Wave model

- describes behavior common to all waves

- **Traveling wave:** organized (collective) disturbance traveling at a well-defined speed, \( v \)

- 3 types:
  
  (i) **Mechanical** (within a material medium) e.g. sound in air, ripples on water

  (ii) **Electromagnetic** (light): oscillation of field, can travel in vacuum

  (iii) **Matter** waves: electron has wave-like characteristics (quantum physics in Phys 270)
Wave model (II)

- **medium**: substance wave moves thru’, elastic, restoring force brings back to equilibrium e.g. tension in string, gravity for waves in water

- **disturbance**: displacement from equilibrium as wave passes (organized motion cf. random motion of thermal energy)

- **wave speed** \((v)\): disturbance travels outward from source, energy (but not material) transferred

- **Transverse waves** (particles move perpendicular to direction of wave: e.g. string) vs. **Longitudinal waves** (...parallel...e.g. chain of masses connected by springs)

- Apply **Newton’s laws** to particles of medium e.g. forces on segment of string: wave speed depends only on material of medium
One-Dimensional Waves

- **Waves on a string:**
  
  function of two variables: \( t \) (when) and \( x \) (which point of wave)

- **“Snapshot” graph**
  
  The string’s displacement as a function of position at time \( t_1 \)

- **History graph**
  
  The string’s displacement as a function of time at position \( x_1 \)

Longitudinal Waves: \( \Delta x \) vs. \( x \)
Displacement function: $D(x, t)$

• “particles” (segment of string, small volume of fluid) of medium displaced from equilibrium as wave travels

- $D(x, t = t_1)$ (function of $x$) = $D(x - vt_1, 0)$, i.e., $D(x, 0)$ shifted by $vt_1$
  $\Rightarrow D$ is function of $(x - vt)$ e.g. $\sin(x - vt)$

- Wave moving to left: $D$ is function of $(x + vt)$