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)

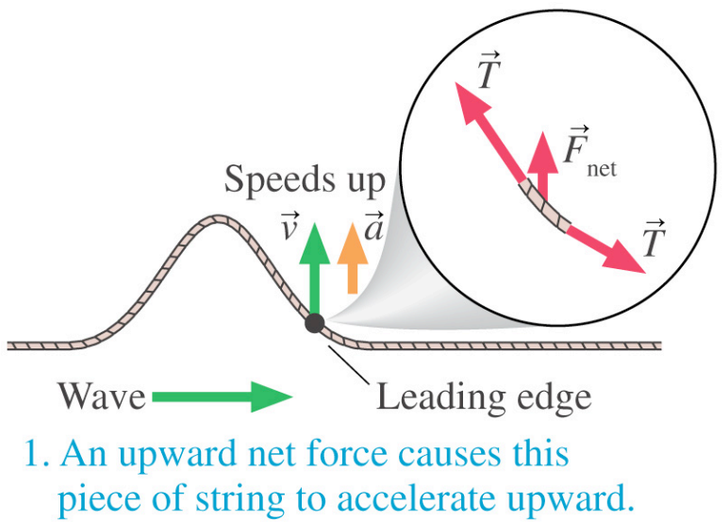
- medium: substance wave moves thru', elastic, restoring force brings back to equilibrium e.g. tension in string, gravity for waves in water

- 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



1. An upward net force causes this piece of string to accelerate upward.

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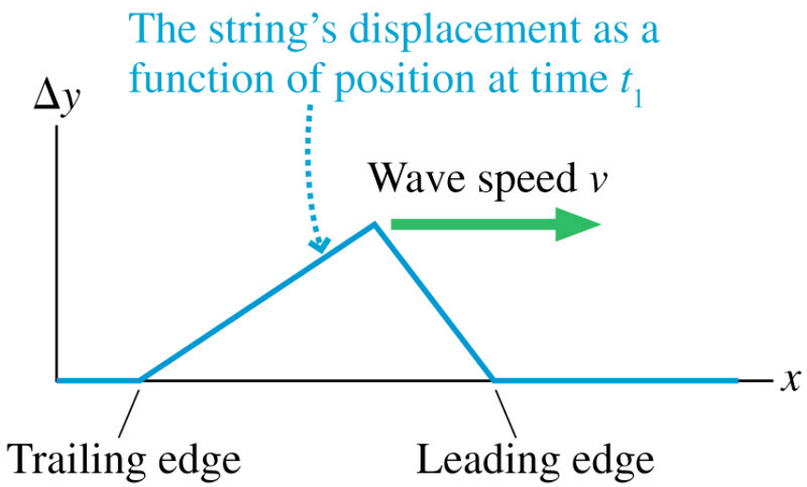
One-Dimensional Waves

- Waves on a string: $v_{\text{string}} = \sqrt{\frac{T_s}{\mu}}$

  function of <u>two</u> variables: t (when)
  and x (which point of wave)

- *<u>"Snapshot"</u>* graph



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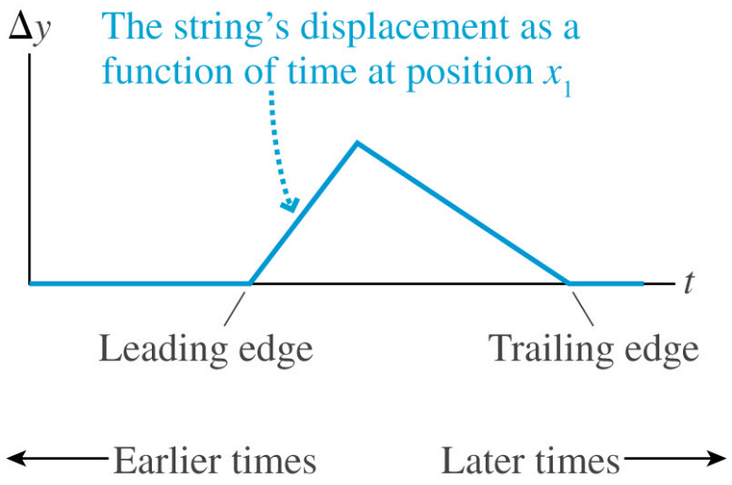
- *<u>History</u>* graph



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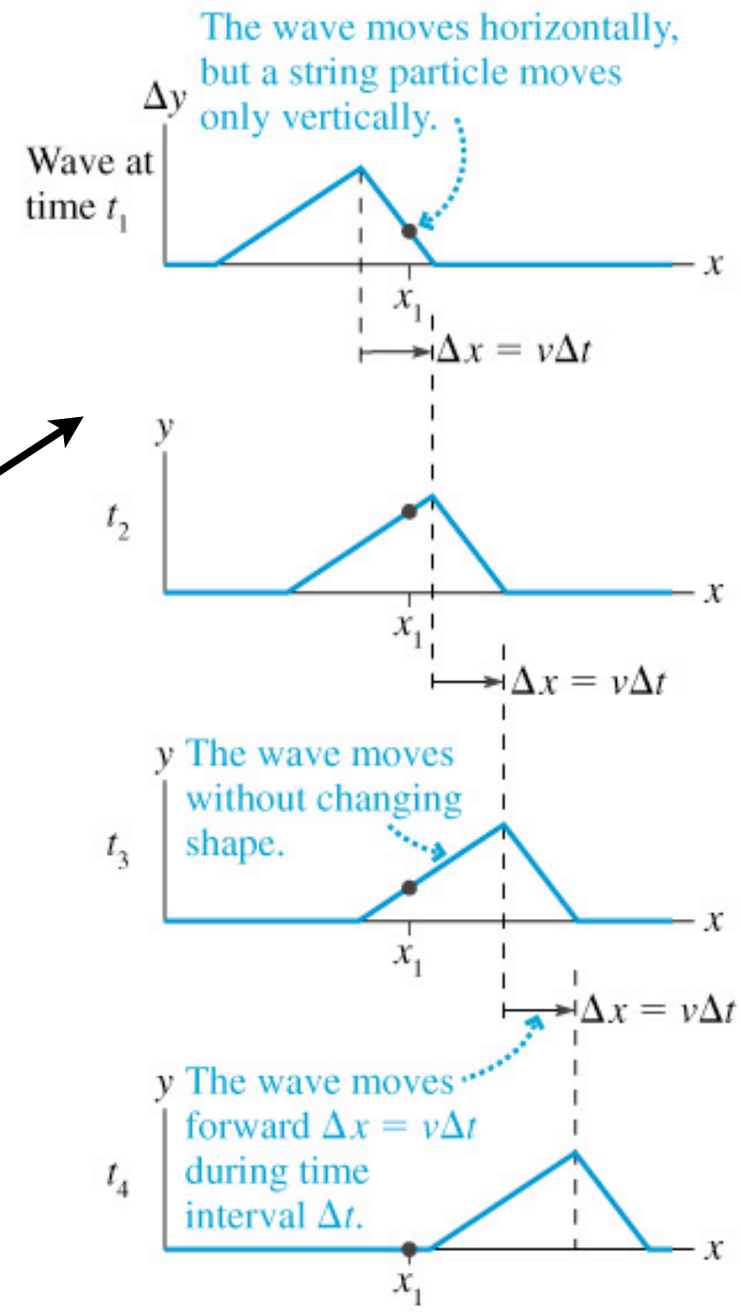
sequence →



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Longitudinal Waves: Δx vs. x

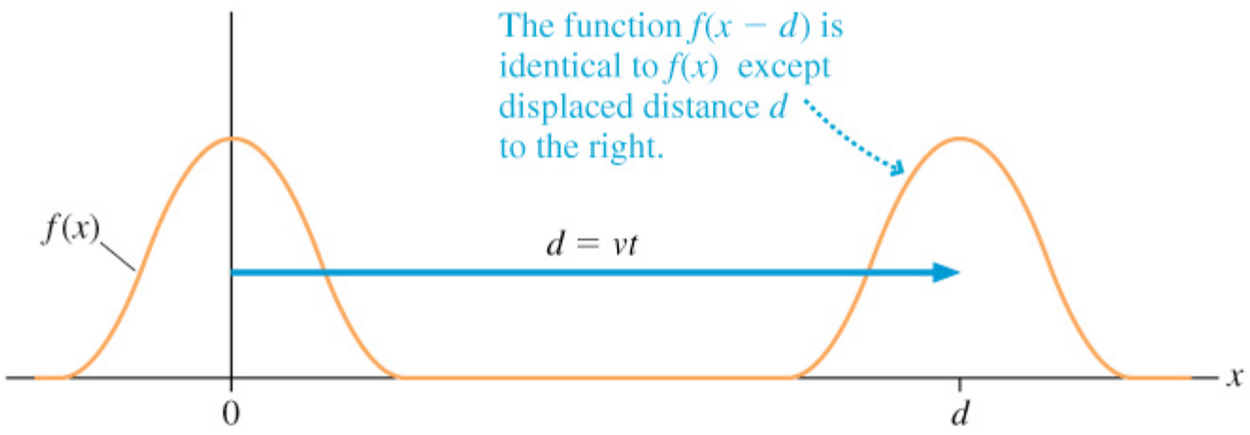
Displacement function: D(x, t)

- "particles" (segment of string, small volume of fluid) of medium displaced from equilibrium as wave travels

snapshot

- $D(x, t = t_1)$ (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. $\sin(x - vt)$



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