General announcements

Simple harmonic motion - summed up

What does it mean to undergo **simple harmonic oscillation?**

A vibration back and forth about an equilibrium point, with a defined amplitude and frequency of oscillation and a *restoring force* that is proportional to minus the displacement of the body from equilibrium.

Examples: spring/mass system, pendulum with small initial angle

What quantities do we have to describe an oscillation?

Angular frequency (rad/s) and frequency (Hz), related by $\boldsymbol{\omega = 2\pi\nu}$

Position vs. time functions, like $\boldsymbol{x = A\sin(\omega t + \phi)}$ and its derivatives

From those derivatives, knowledge that $\boldsymbol{v_{max} = \omega A}$ and $\boldsymbol{a_{max} = \omega^2 A}$

For a spring mass system, $\boldsymbol{\omega = \sqrt{k/m}}$ and for a pendulum, $\boldsymbol{\omega = \sqrt{g/L}}$

Period of oscillation is the inverse of frequency, or $\boldsymbol{T = 1/\nu}$

Resonance

A vibratory system will have natural frequencies at which it will oscillate if set into motion.

Example: we've already seen that a hanging spring with a mass attached to one end has only one frequency it will oscillate at no matter what the displacement of the mass. Although hat one frequency is the single natural frequency of oscillation for that system, there do exist systems that have more than one natural frequency.

A system can be forced to vibrate by an outside force (hitting a tuning fork with a mallet, for instance).

An outside force can be periodic having having a frequency of application associated with it.

If the frequency of an applied force happens to match one of the natural frequencies of a system, energy is poured into the system by the force in a coherent way and the amplitude of motion gets bigger and bigger.

This phenomenon is called **RESONANCE**!

Examples of resonance?

- *Pushing a* child on a swing – when should you push?
- *Instruments* – cello string vibrates, causes wood to vibrate at same frequency and sound amplifies
- *Sea shells sounding* like the ocean – it amplifies the ambient noise in the room
- *Demo: tuning forks*
- *Demo: Chladni plate*
- *Breaking glass with sound* –
- http://techtv.mit.edu/videos/2964-breaking-glass-with-sound

Tacoma Narrows Bridge collapse

Wave velocity

We saw in that video (and you know in real life) that light waves travel more quickly than sound waves. All waves travel one wavelength in one period – if we divide those values, it gives us a wave velocity!

$$\frac{\lambda}{\mathrm{T}} = \text{velocity in m/s}$$

Instead of period, we often know frequency. As $T = \frac{1}{\nu}$, substitution into the above relationship yields the general expression:

$$\boxed{\boldsymbol{v = \lambda\nu}}$$

This is known as the wave velocity equation, and it holds true for all types of waves. For a wave in a given medium, the velocity is constant – if the medium changes, so will velocity.

Waves

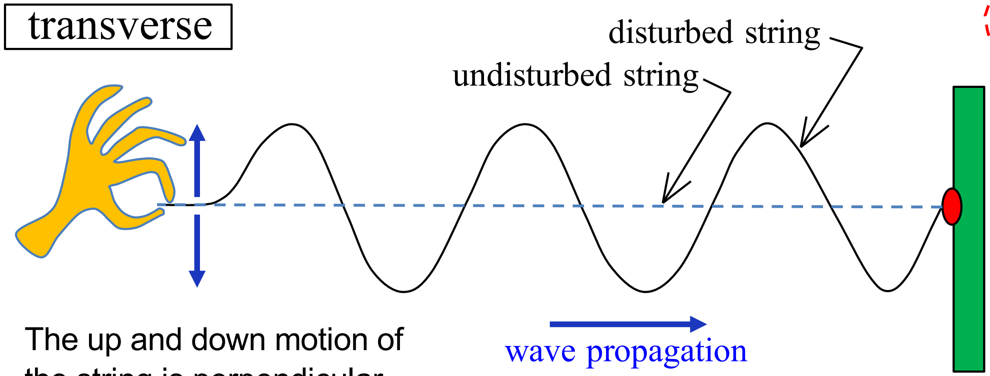
Mechanical waves are the propagation of a DISTURBANCE through a medium.

Note that light is not a mechanical wave as it has no medium through which it propagates—we'll talk about electromagnetic waves later . . .

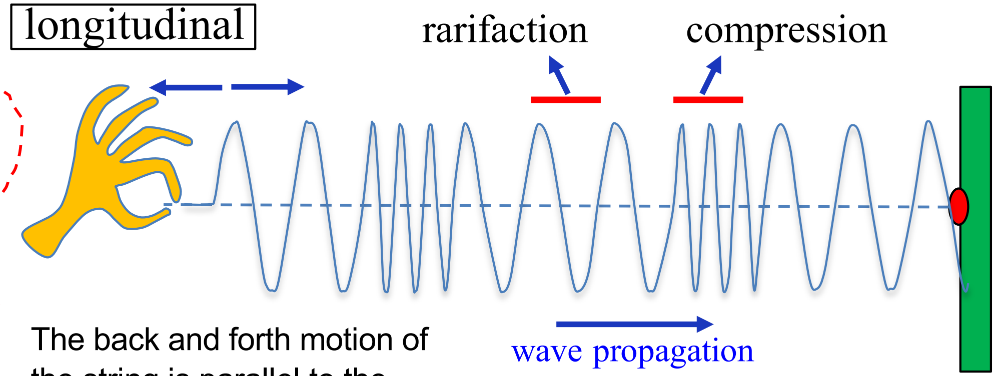
Note also that what makes waves useful is that they all carry energy . . .

A transverse waves is a mechanical wave that is produced by a force that is applied perpendicular to the direction of the wave's propagation through its medium.

A longitudinal waves is a mechanical wave that is produced by a force that is applied parallel to the direction of the wave's propagation through its medium.



The up and down motion of the string is perpendicular to the direction of wave propagation



The back and forth motion of the string is parallel to the direction of wave propagation

Transverse waves

Transverse waves are classified by their

- *Amplitude:* maximum displacement from equilibrium to a crest (or trough)
- *Wavelength:* distance between two identical points on the wave (crest/crest, trough/trough, midpt/midpt)

Classic examples are:

- *Shaking a rope* or slinky side to side
- *Dropping a stone in a pond* and watching the ripples go outward
- *S-waves* in an earthquake

We'll use the rope analogy most when representing waves because it's easier to visualize, but they're not the only type!

Longitudinal Waves

Longitudinal waves are classified by their

- *Compressions and rarefactions:* areas of minimum and maximum density as the medium vibrates. Amplitude can be found if you can measure how much a point moves from equilibrium to maximum compression or extension.
- *Wavelength:* distance between successive compressions or rarefactions

Classic examples are:

- *Scrunching up* an extended slinky and letting it go
- *Sound waves*
- *P-waves* in an earthquake

All longitudinal waves require a medium! Why? What problem does this bring up in modern cinema? Sorry, Star Wars…

Visualizing longitudinal waves

A longitudinal wave does not physically have a sinusoidal look to it. In the case of sound where the disturbance is a variation in air pressure that moves through, say, a room, the *look* is that of a region of dense air bracketed by regions of less or more dense air on either side. If you take a snapshot of such a situation, though, and map the density from point to point, you will find the graph produced will be sinusoidal.

The example to the right is of a sound wave's pressure-variations plot, as lifted from Fletch's text.

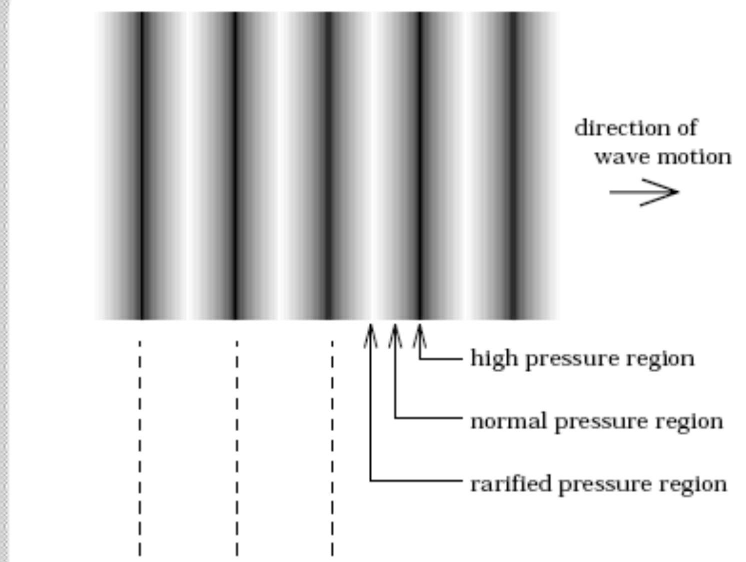
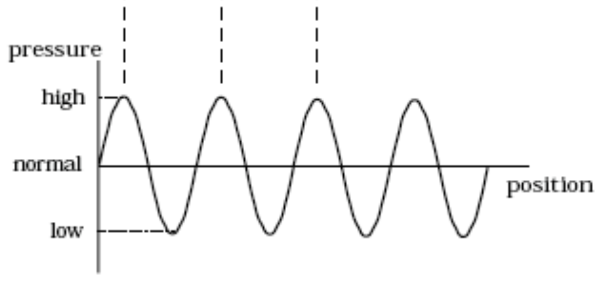


FIGURE 12.2a



Pressure versus Position Graph for SOUND WAVES
(at a given instant in time)

FIGURE 12.2b