WAVE PARAMETERS

MU610A: ACOUSTICS & PSYCHOACOUSTICS

EDWARD COSTELLO

LAST WEEK RECAP:

What is sound?

- Compression and Rarefaction
- Velocity
- The Golf Ball and Spring Model
- Propagation
- Longitudinal and Transverse waves
- Young's Modulus
- Attenuation

FUNDAMENTAL ITEMS

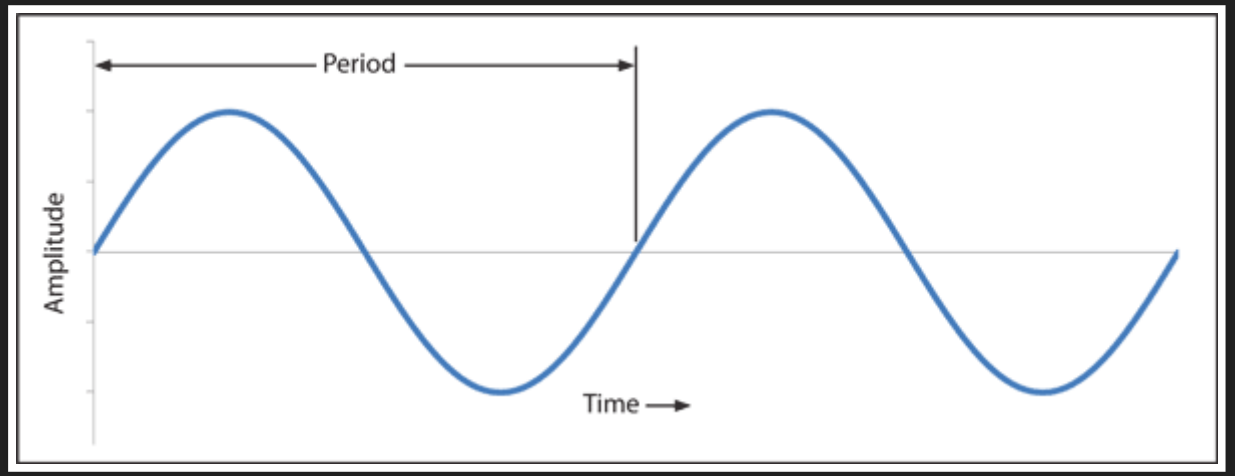
- Periodic Waves
- Period
- Frequency
- Wavelength
- Amplitude
- Phase/Phase offset
- Sinusoid waves
- Velocity revisited

SOUND WAVES

- Sound waves are pressure waves (based on the compression and rarefactions of molecules) which travel through a medium.
- They propagate as longitudinal waves and travel through the medium at a constant speed depending on characteristics ('springiness', density) of the medium.
- The simplest type of sound waves is a periodic type...in other words, it has a repeating pattern.

SOUND WAVES

- The following diagram can be viewed beside the previous analogy of the golf ball and spring model to describe sound propagation. The peaks above the x axis can be thought of as pressure peaks when the golf balls are pushed together and troughs represent moments of rarefaction.


Period
Amplitude
Time

WAVE PARAMETERS

The simplest form of sound wave, (periodic waveforms) have the following parameters.

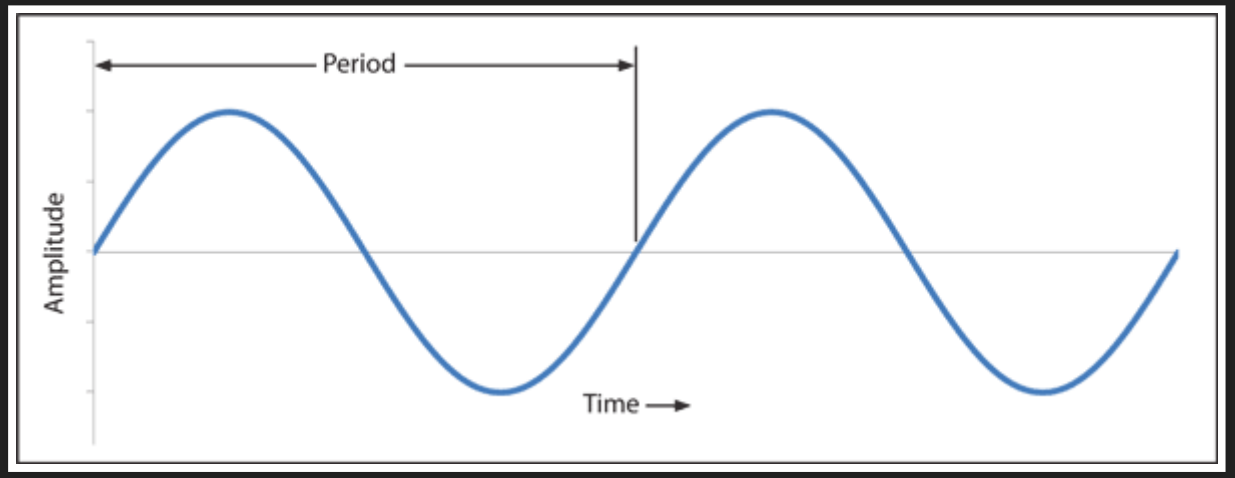
- Period: Time for a single repetition. It is represented by T
- Frequency: The rate of repetition, measured in Hertz (Hz)
- Wavelength: A measure of how long a cycle. Represented by the greek letter lambda λ e.g. 440Hz sound λ in air is about 77.8cm

WAVE PARAMETERS

- Amplitude: The amount of displacement from normal state of the medium.
- Phase (starting position): the starting point of a wave. (eg: A sine wave would have a phase offset of zero degrees. A cosine wave would have a phase offset of 90 degrees). These parameters will have an effect on the nature of the sound produced and (most of the time) how perceive the sound.

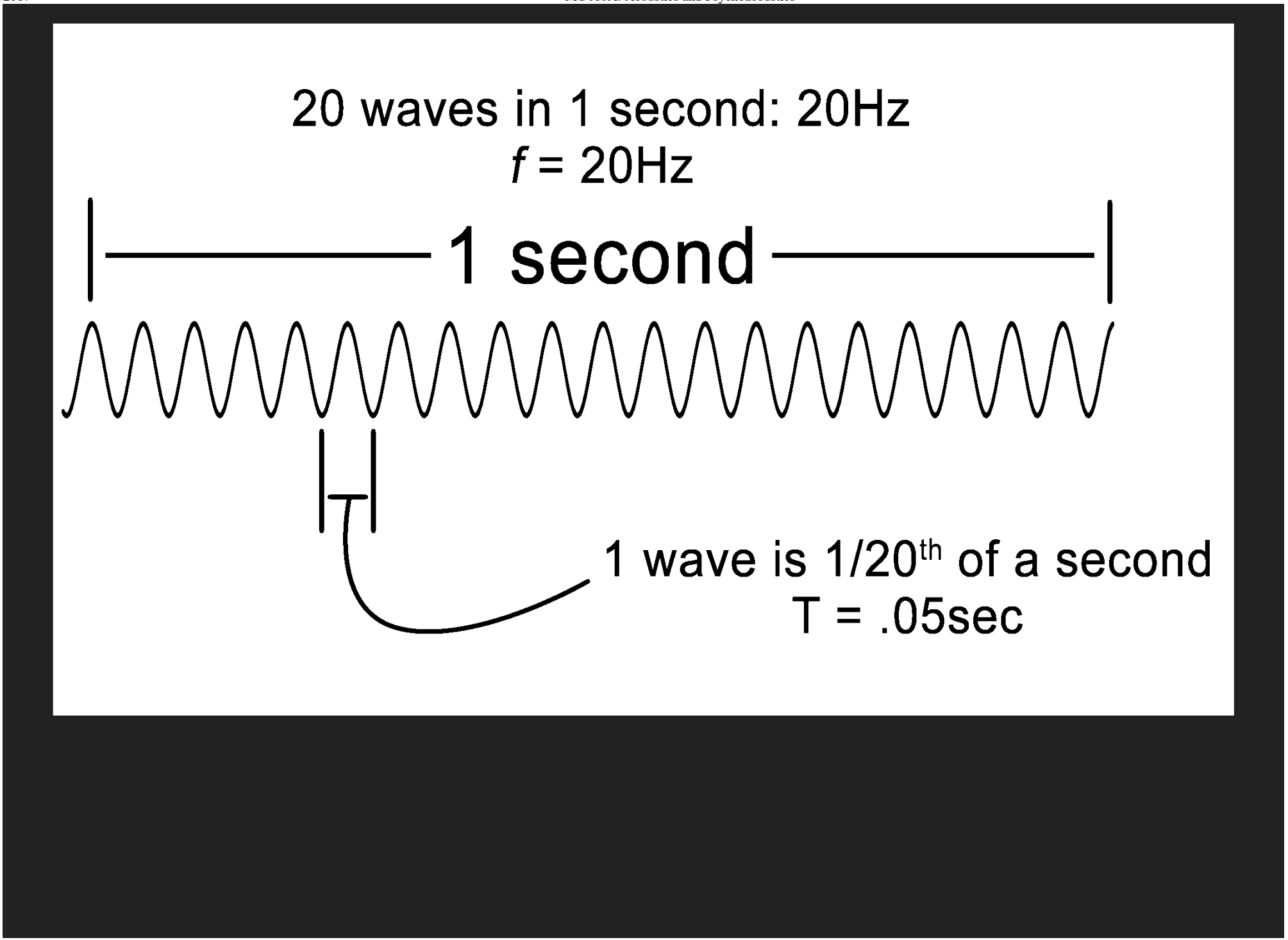
PERIOD

- Period is the time taken for a single repetition of the wave. (represented by T)
- On the graph below time is represented on the horizontal axis.



FREQUENCY

- While period is the time taken for a single repetition of the wave. (represented by T)
- Frequency is the amount of repetitions of a waveform over a given time, Hz is repetitions per second


20 waves in 1 second: 20Hz
f = 20Hz
1 second
1 wave is 1/20th of a second
T = .05sec

FREQUENCY

- Frequency is related to pitch in simple terms
- The average human being can only perceive frequencies from 20Hz up to 20KHz (20,000Hz). You may be familiar with 'concert A' pitch which vibrates at 440Hz.

FREQUENCY

- Our perception of hearing mainly diminishes over time due to two main factor.
  1. Age: Slowly our frequency range diminishes and we can't hear very high/ very low frequencies (exercise)
  2. Overexposure to very high audio levels. Hearing damage tends to be irreparaple. This will be covered in the psychoacoustics element of the course.

FREQUENCY

- Wavelength is a measure of how long a wave cycle is. It is represented by the Greek letter lambda λ
- As you can see the horizontal axis is the distance (not time), so the wavelength is basically the size of the wave.
- It can be used as a ruler when we are calculating distances and sizes of acoustic spaces.

AMPLITUDE

- Amplitude is the maximum deviation from the normal state of the medium. In the context of sound waves, it will refer to the change in air pressure.
- It can be seen as the as the amount of acoustic energy in the sound.
- The amplitude of a wave corresponds roughly to our sense of the 'loudness' of the stimulus created by it

AMPLITUDE

The amplitude can refer to two things:

1. The different instantaneous values of amplitude at a point along the wave path, the difference between two values in series
2. The peak amplitude, or how much the wave varies above and below a certain average (the atmospheric pressure)

PEAK AMPLITUDE AND RMS

- RMS (Root Mean Squared) amplitude is another way of describing the amount of sound energy in a wave.

The relationship between RMS amplitude and Peak amplitude values will vary depending on the nature of the wave.

PEAK AMPLITUDE AND RMS

- RMS is calculated by squaring the amplitudes at each point of a waveform and then taking the root of a mathematical average. The squaring eliminates the negative values (if we just added all values, we would get 0).

PEAK AMPLITUDE AND RMS

- For sine waves (the waves we are most interested in at the moment), if we calculate the RMS amplitude of a wave with a peak amplitude of 1, we'll come up with a value of 0.707.

RMS amplitude = Peak amplitude $\times$ 0.707

That is a sine wave given by $y = A_1 sin(2\pi f t)$ will have an equivalent RMS given by $\frac{A_1}{\sqrt{2}}$

PEAK AMPLITUDE AND RMS

- Other waves will have different results, but can be estimated using this sine RMS value, as seen above. Nevertheless, the RMS pressure amplitude is what we mean when we talk about Sound Pressure Level (SPL) which we will be discussing later in the course.

PHASE

- Phase (or phase offset) is, simply put, the starting point of a wave within the context of it's characteristic shape. Standard sine waves start on the axis and rise to full positive amplitude from that point.
- A so-called sinusoidal wave that starts at an offset of 90 degrees starts at the point of maximum amplitude and works downwards.

PHASE

- A wave which is at a 180 degrees offset will start at the axis and work downwards. If combined with a wave which has a zero degree offset, the two will completely cancel eachother out. This offset is commonly known as 'out of phase', although strictly speaking any difference in the starting point results in the two waves being 'out of phase'

PHASE

- The symbol for phase is ϕ, which can be seen on mixing desks in relation to compensating for timing difference in the signals from the space microphones. This will allow for the phase of the input signal to be reversed.

THE SINSOIDAL SINE/COSINE WAVE

- Why chose the sine wave when studying acoustics?
  - Simplicity in terms of make-up
  - Influence of Fourier Analysis
- A sine wave can be plotted be generated by plotting the movement of a wheel.

THE SINSOIDAL SINE/COSINE WAVE

- The sine wave is a part of the sinusoidal family of waves, which is a whole class of waves with this smooth, circular shape. The sine wave is simply a sinusoidal wave that starts at zero and travels upward to its maximum, and so on.