SOUND AND HEARING

Sound – longitudinal waves traveling thru solid, liquid or gas.

Acoustics – branch of physics that deals with the relationship between the physical characteristics of a sound like amplitude, frequency, wavelength, intensity, etc and the human sense of hearing

Acoustic Phenomena – the events that involve sound as it affects human sound perception like beats, interference, and Doppler’s effect.

Audio Frequency (AF) – frequency of waves ranging from 20 to 20,000 Hz which human ear can respond to.

Ultrasonics – those waves of frequencies above the AF.

Infrsonics – those waves of frequencies below the AF.

Characteristics of Sound:

1. Pitch or Tone – that property of sound directly related

to frequency

1. Quality of sound – that property of sound directly

associated with the complexity of the wave form

* Complexity – a measure of the deviation of a sound wave from the ideal smooth sinusoidal wave.

1. Loudness of sound - that characteristic of sound

directly related to the amplitude of the waves.

* Refers to the listener’s subjective perception of the magnitude of a sound sensation or the strength of the sensation received by the ear.
* High amplitude sound waves are loud sound

1. Intensity of Sound (I) – the time rate at which sound

energy is transmitted by the waves per unit area of a surface placed perpendicular to the direction of the waves

* Power transmitted per unit area (watts/m2)

**I =**

**I = BωkA2**

**I =**

where: v = velocity ;

⍴ = density

Pmax = pressure amplitude in Pa

Pmax = BkA

where: B = bulk modulus

k = wave number

A = displacement amplitude

* Pressure amplitude – maximum variation from atmospheric pressure of the air pressure near the eardrums

Maximum pressure amplitude – the loudest sound that the human ear can tolerate (30 Pa)

Minimum pressure amplitude – the faintest sound that can be heard by the human ear (3 x 10-5 Pa)

Intensity Level or Noise Level (Β)

* Logarithmic evaluation of the intensity of sound waves
* The unit is decibel (dB)

**β = 10log()**

where: I0 = reference intensity = 10-12 W/m2

* Threshold of hearing – minimum noise level that can be heard by the ear (0dB)
* Threshold of pain – maximum noise level that the human ear can withstand (120dB)

**ACOUSTIC PHENOMENA**

1. Beats

* Variation in amplitude of sound waves due to the alternate constructive and destructive interference of two sound waves of slightly different frequencies reaching the ears at the same time.

Beat Frequency (fB) – frequency of the variation

**fB = |f1-f2|**

where: f1 = slightly higher frequency

f2 = lower frequency

1. Doppler’s Effect

* The change in frequency of the sound as it is received due to the relative motion between the source and the receiver.

**fR = fS**

where: fR = frequency of sound received by the

listener/receiver

fS = frequency of sound emitted by the source

Vw = speed of the wave

VR = speed of the receiver

+VR if receiver is moving towards the source

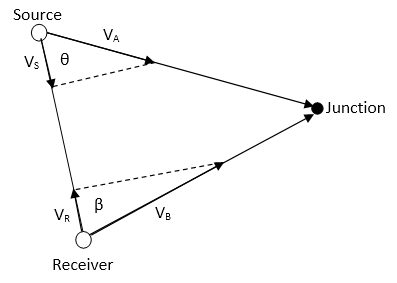
-VR if receiver is moving away from the source

VS = speed of the source

+VS if source is moving away from the receiver

-VS if source is moving towards the receiver

* In cases where the source and the receiver are not moving along the same line, VS and VR are the components of the actual velocities of the source and the receiver along the line connecting them at the instant sound was emitted.



SAMPLE PROBLEMS

1. Calculate the pressure amplitude of a 2 KHz sound wave in air, assuming that the displacement amplitude is equal to 2 x 10–8 m.
2. The power output of a certain public-address speaker is 6.00 W. Suppose it broadcasts equally in all directions. (a) Within what distance from the speaker would the sound be painful to the ear? (b) At what distance from the speaker would the sound be barely audible?
3. The sound intensity at a distance of 16 m from a noisy generator is measured to be 0.25 W/m2. What is the sound intensity at a distance of 28 m from the generator?
4. The sound level at a distance of 3 m from a source is 120dB. At what distance is the sound level (a) 100 dB and (b) 10 dB?
5. An automobile moving at 30.0 m/s is approaching a factory whistle that has a frequency of 500Hz. (a) If the speed of sound in air is 340 m/s, what is the apparent frequency of the whistle as heard by the driver? (b) Repeat for the case of the car leaving the factory at the same speed.
6. An ambulance moving at 42 m/s sounds its siren whose frequency is 450 Hz. A car is moving in the same direction as the ambulance at 25 m/s. What frequency does a person in the car hear (a) as the ambulance approaches the car? (b) After the ambulance passes the car?
7. A tuning fork of frequency 400 Hz is moved away from an observer and toward a flat wall with a speed of 2.0 m/s. What is the apparent frequency (a) of the unreflected sound waves coming directly to the observer, and (b) of the sound waves coming to the observer after reflection? (c) How many beats per second are heard? Assume the speed of sound in air to be 340 m/s.
8. Car A is traveling due East at 10m/s and is 30m past the crossing when it blows its horn at 400Hz. At the same instant, car B is traveling at 20m/s 60O S of E and is moving away from the crossing. If car B is 40m from the crossing and sound travels at 350m/s, what frequency is received by car B?