**16-1**

- Sound waves
  - longitudinal
  - mechanical; travel in solids, liquids, and gases; can't travel in outer space because there is no medium
  - start with vibrations
    ~ as drum or guitar string vibrates, they cause disturbance in air molecules (compressions and rarefactions)
    ~ the larynx (voice box) is made of 2 folds (vocal cords); as you force air through larynx, the vocal cords vibrate and cause compressions to form
  - undergo diffraction and reflection (echo)
  - speed: to be pleasant, sounds produced in a band should reach your ear at the same speed. The speed depends on
    a. elasticity: the ability to bounce back after disturbed
       sound travels faster in elastic mediums because when the particles are compressed, they soon spread out again; fastest in solids
    b. density: mass per volume
       sound waves travel faster in less dense mediums because of less mass per volume
    c. temperature: measure of the average kinetic energy of particles in matter
       sound waves travel faster at higher temperature because the particles move faster

- Read page 502.

**16-2, 3**
**Properties of Sound**

- Intensity: amount of energy the wave carries per second through a unit area (Watts/square meter)
  The higher the amplitude, the more the intensity

- Loudness: the sound level heard (decibels – dB)
  The greater the intensity, the louder it is

- Frequency: the number of vibrations per second (Hertz – Hz)
  When the vocal cords are stretched, they vibrate more often as the air rushes past them creating high-frequency waves. When the cords are relaxed, they vibrate less often producing low-frequency waves.
  Sound waves with frequencies above the normal human range (20-20,000 Hz) are called ultrasound and the ones below the normal range are called infrasound.

- Pitch: how high or low the sound seems to a person
  Sound waves of high frequency have a high pitch and vice versa.
  The pitch depends on the material used, the length of the string (the longer the lower pitch), the thickness of the string (the thicker the lower pitch),and the tightness of the string (the tighter the higher pitch).

- Resonance: when the frequency of the sound waves and the natural frequency of an object they go through match and the waves interfere constructively, ex. opera singer's voice shatters the glass since it is not as elastic.

- Doppler Effect: the apparent change in frequency of a wave source in relation to the listener
  As the wave moves toward the listener, the waves reach the listener with higher frequency and pitch.
  As a plane travels almost as fast as the speed of sound, the sound waves pile up in front of the plane (sound barrier). When the plane

flies faster than the speed of sound, it breaks this barrier releasing a huge amount of energy in the form of a shock wave. People on the ground hear a loud noise called a sonic boom.

- Interference: when sound waves meet constructively, a louder sound results. If they meet destructively, a softer or no sound is the result. Acoustics describes how well sounds can be heard in a room/hall. When designing auditoriums, acoustical engineers must consider the shape of the room and the materials in it. Some materials absorb sound rather than reflect and eliminate the reflected waves that cause interference.
  Some airline earphones use destructive interference to cancel out the steady engine noise.
  Sometimes the sound waves interfere both constructively and destructively resulting in louder and softer sounds at regular intervals. The repeated changes in loudness are called beats. Piano tuners use beats to tune the piano until no beats can be heard.
  Unlike music, noise is a mixture of unpleasant sounds and involves sound produced when notes that have no musical relationship are played together (dissonance).

**16-4**

- know briefly how you can hear sound
- hearing loss is due to
  - injury: when the bones can be disconnected or when the eardrum gets punctured by putting things in the ear
  - infection: by bacteria/viruses
  - aging: the tiny hairs in the inner ear become less effective
  - exposure to loud sound: kills the nerve cells attached to the hairs, and messages are unable to go to the brain through the auditory nerve

  Some loss can be helped with hearing aids, others can be corrected by surgery.

## 16-5
## Applications of Sound

- Infrasound: used by elephants when they stomp on the ground after getting upset in order to communicate with other elephants.
- Ultrasound
    - SONAR (**so**und **n**avigation **a**nd **r**anging): measures the time it takes to detect the reflected sound waves; the data can be used to calculate the distance the sound has traveled and know about the size/shape of object.
    - Echolocation is the use of sound waves to determine distances and locate objects; used by dolphins, whales, and bats to navigate and find prey
    - Fishermen use ultrasonic devices to annoy dolphins and move them away from their nets.
    - Divers use ultrasonic devices to be protected from sharks.
    - Doctors use ultrasound to look inside the human body and to diagnose and treat medical conditions. The picture is called a sonogram.
    - At home, ultrasound is used in electric toothbrushes, jewelry cleaners, and some cameras with automatic focusing.