The Senses
The Skin

- The skin is the sensory organ responsible for touch.
- This organ covers the entire surface of the body.
- Your skin can be divided into 3 parts
  - Epidermis
  - Dermis
  - Hypodermis
Structures of the Epidermis

- **Dead layer**
  - Outer layer of skin

- **Living layer**
  - This layer consists of the constantly dividing cells.
  - The new cells push the older cells to the surface
Structures of the Dermis

- **Sensory receptors**
  - Structures that pick up the stimuli

- **Blood vessels**
  - Vessels that nourish the skin cells

- **Sebaceous glands**
  - Glands that secrete sebum, an oily substance that waterproofs the skin

- **Sweat glands**
  - Glands that produce sweat, which is carried to the surface through pores

- **Hair**
  - Structures arising from the dermis and partially covering the epidermis.
  - An adjacent muscle can contract, making the hair stand and cause goosebumps
Structure of the Hypodermis

- Fat cells
  - Layer of fat containing cells that act as an energy reserve and a thermal insulator.

- The sensory receptor in the skin are responsible for the following:
  - Tactile sensation (touch, pressure)
  - Thermal sensation (heat and cold)
  - Painful sensations (pain)

- Each different sensation has its own nerve ending.
The Eye

- You have 2 eyes to give you depth perception.
- Babies are born colourblind. (More common in males)
- Babies do not produce tears until 6 weeks old.
- Under optimal conditions, humans can see the light from a candle over 20 km away
- Your eyes are incredibly fast, fastest muscles in your body. You can blink up to 5 times in a second.
The Eye

- The eye is a sensory organ responsible for vision.
- It picks up light from the environment which are then focused on the back of the eye.
- We will discuss the various structures of the eye and their function.
Eye

- Sclera is the rigid, opaque membrane which is about 1mm thick. It protects the eye from shock, gives it its shape and is commonly referred to as the white of the eye.

- The choroid is the middle layer of the eye. It contains the blood vessels that nourish the eye.

- The retina is the innermost layer at the back of the eye. It is covered in millions of light-sensitive nerve cells.
Eye

- The blind spot is where the retina meets the optic nerve. There are no nerve cells there in that spot.

- The cornea is the clear rigid membrane that is the extension of the sclera.

- The iris is an extension of the choroid. This is the pixilated membrane with an opening called the pupil. This regulates the amount of light that enters the eye.
Eye

- The lens is a flattened sphere that focuses the light rays on the retina. It is held in place by muscles, which flatten or round out the lens and change how the light is focused.

- The aqueous humour is a liquid that fills the space between the cornea and lens.

- The vitreous humour is a jelly-like substance that fills the space between the lens and the retina.
Eye

- The receptors on the retina are called rods and cones.
- The cones are used to distinguish colour.
- The rods are used to distinguish variations in light.
- The rods and cones are not evenly distributed evenly throughout the retina.
- The fovea contains most of our cones while the rest of the retina contains the rods.
Waves

- Waves are disturbances that travel through a medium.
- Waves only transmit energy, not matter.
- Waves propagate (spread) in 2 ways.
  - Transverse
  - Longitudinal
Transverse Waves

- A transverse wave is a wave that propagates perpendicularly to the motion of the medium.

- The peak of the wave is called the crest and the bottom is called the trough.
A longitudinal wave is a wave that propagates parallel to the motion of the medium.

The parts of the waves which are closer is called compression and the parts that are further apart are the rarefaction.
Amplitude

- The amplitude of a wave corresponds to the maximum distance travelled by a particle in the medium compared to its position at equilibrium.
The wavelength is the length of a wave’s complete cycle. Wavelength is shown by the symbol $\lambda$. 
Frequency

- Frequency corresponds to the number of cycles per unit of time.

- Frequency is measure in hertz (Hz) which is the number of cycles per second.
Visible light is only a small portion of the electromagnetic spectrum.

Light can reflect off of an object.

This is how we see an object, by observing the light which reflects off of it.
Reflection

A reflection is the rebounding of light that occurs when a light ray hits a different medium and bounces back to the medium from which it came.

There are 5 terms that we will define regarding reflection.

- Incident ray
- Reflected ray
- Normal line
- Angle of incident
- Angle of reflection
Incident and Reflected Ray

- The incident ray is the ray of light hitting the object.

- The reflected ray is the ray of light which comes off the object towards your eyes.
Normal and the Angles

- The angle of incidence is the angle at which the light hits the object.

- The normal is a line which is perpendicular to the surface.

- The angle of reflection is the angle at which the light is reflected off of the object.

- Both angles are exactly the same.
Reflection

Angle of Incidence equals Angle of Reflection

Incident Ray:

Reflected Ray:

PLANE MIRROR
Refraction

- Refraction is the deviation of light as it passes from one medium to another.

- This is due to the fact that the light slows down.

- This is what make it seem that an object is “broken”
Refraction

\[ n_1 \ \text{sine} \ \alpha = n_2 \ \text{sine} \ \beta \]
Refraction
Lenses

- Lenses are objects made of transparent materials that have at least one curved surface.

- There are two types of lenses:
  - Convergent
  - Divergent
Convergent Lenses

- Convergent lenses are lenses that bring rays together.

- There are three types of convergent lenses
  - Biconvex
  - Plano-convex
  - Meniscus
Divergent Lenses

- Diverse lenses disperse light rays.

- There are three types of divergent lenses:
  - Biconcave
  - Plano-concave
  - Meniscus
Lens Types

CONVERGING LENSES
- convex lens
- biconvex lens
- plano-convex lens
- positive meniscus

DIVERGING LENSES
- concave lens
- biconcave lens
- plano-concave lens
- negative meniscus
The Focal Point

- The focal point is where the light is focused by a lens.

- In a convergent lens, it is the real point where the refracted rays actually meet.

- In a divergent lens, it is a virtual point where the light rays appear to originate.
Converging Focal Point
Divergent Focal Point

Refraction of light through a diverging lens

Focal point

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A “normal” individual who has “normal” vision, is said to have 20/20 vision.

In this case, the image from the eye is focused on the back of the eye on the retina.

There are two common vision defects:
- Myopia
- Hyperopia
Myopia

- Myopia, also known as nearsightedness, the eye is too long.

- This causes the image to be focussed in front of the retina.

- They cannot see objects that are far.

- To correct this problem, divergent lenses are used.
Myopia
Hyperopia

- Hyperopia, known as farsightedness, the eye is too short.
- The image is focussed behind the retina.
- They cannot see objects that are close.
- To correct this problem, they use convergent lenses.
Hyperopia
The Ear

- The ear is the sensory organ responsible for hearing.

- It picks up the sound and converts it to nerve impulses.

- The ear is divided into three parts
  - Outer Ear
  - Middle Ear
  - Inner Ear
Structures of the Outer Ear

- **Pinna**
  - The visible part of the ear.
  - Shaped like a funnel to more easily pick up the vibrations in the air.

- **Auditory Canal**
  - Slightly curved, 2.5 cm long canal that carries the sound vibrations to the eardrum
  - It is lined with tiny hairs and sebaceous glands, which produce the wax, to prevent foreign bodies from entering the ear.
Structures of the Middle Ear

- **Tempanic membrane (eardrum)**
  - Thin, flexible and fibrous membrane about 1cm in diameter
  - Moves to the rhythm of the sound wave vibrations

- **Ossicles (bones)**
  - Miniature bones are located in the temporal bones
  - The three bones are the hammer, anvil and stirrup

- **Eustachian tube**
  - Canal that links the middle ear to the throat.
  - Used to equalize the pressure in the ear when swallowing.
Structures of the Inner Ear

- **Semi-circular canals**
  - Canals that form a liquid-filled labyrinth in the temporal bone
  - They regulate balance when the body is in motion.

- **Vestibule**
  - Liquid-filled structure that link the semi-circular canals to the cochlea.
  - The vestibule plays a role in balance when in a static position.

- **Cochlea**
  - Liquid-filled structure whose walls are covered with auditory nerve cells linked to the auditory nerve.
Structure of the Ear
Sound Waves

- Sound is a longitudinal mechanical wave produced by the vibration of an object and transmitted to the object’s environment.

- The sound is a series of compression waves.
Sound Waves

- We hear sound because the sound waves cause the eardrum to vibrate.
- These vibrations then go through the ossicles and then it is interpreted as sound by the brain.
- Sound waves, being a mechanical waves, need a medium to propagate.
The Speed of Sound

- The speed of sound, in air, is 340 m/s or 1224 km/h
- This is also known as Mach 1.
- Double the speed of sound is called Mach 2
- The speed of sound depends on the medium in which it is transmitted.
# The Speed of Sound

<table>
<thead>
<tr>
<th>Medium</th>
<th>Speed (m/s)</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>346</td>
<td>1246</td>
</tr>
<tr>
<td>Water</td>
<td>1490</td>
<td>5364</td>
</tr>
<tr>
<td>Plastic</td>
<td>1800</td>
<td>6480</td>
</tr>
<tr>
<td>Wood</td>
<td>4000</td>
<td>14400</td>
</tr>
<tr>
<td>Steel</td>
<td>5200</td>
<td>18720</td>
</tr>
</tbody>
</table>
The Decibel Scale

- The decibel scale is a relative scale that represents the perception of the intensity of sound by the human ear.

- With this scale, variations are measured by a factor of 10.

- From 0 to 10, the sound is 10 times louder.

- From 0 to 20, the sound is 100 times louder.
Decibel Scale

- Prolonged exposure to sounds louder than 100 dB can cause long-term hearing damage.

- Starting around 120 dB, sound can cause pain and immediate loss of hearing.

- Stop listening to your music so loud!
Frequency and Perception of Sound

- The pitch, or frequency, of a sound depends on its wavelength.
  - Shorter wavelength = Higher pitch
  - Longer wavelength = Lower pitch
- Anything too low for us to hear is considered to be infrasound and anything too high is ultrasound.
## Hearing Ranges

<table>
<thead>
<tr>
<th>Animal</th>
<th>Hearing range in Hertz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans</td>
<td>20 – 20,000</td>
</tr>
<tr>
<td>Bats</td>
<td>2000 – 110,000</td>
</tr>
<tr>
<td>Elephant</td>
<td>16 – 12,000</td>
</tr>
<tr>
<td>Fur Seal</td>
<td>800 – 50,000</td>
</tr>
<tr>
<td>Beluga Whale</td>
<td>1000 – 123,000</td>
</tr>
<tr>
<td>Sea Lion</td>
<td>450 – 50,000</td>
</tr>
<tr>
<td>Harp Seal</td>
<td>950 – 65,000</td>
</tr>
<tr>
<td>Harbor Porpoise</td>
<td>550 – 105,000</td>
</tr>
<tr>
<td>Killer Whale</td>
<td>800 – 13,500</td>
</tr>
<tr>
<td>Bottlenose Dolphin</td>
<td>90 – 105,000</td>
</tr>
<tr>
<td>Porpoise</td>
<td>75 – 150,000</td>
</tr>
<tr>
<td>Dog</td>
<td>67 – 45,000</td>
</tr>
<tr>
<td>Cat</td>
<td>45 – 64,000</td>
</tr>
<tr>
<td>Rat</td>
<td>200 – 76,000</td>
</tr>
<tr>
<td>Opossum</td>
<td>500 – 64,000</td>
</tr>
<tr>
<td>Chicken</td>
<td>125 – 2,000</td>
</tr>
<tr>
<td>Parakeet</td>
<td>200 – 8,500</td>
</tr>
<tr>
<td>Horse</td>
<td>55 – 33,500</td>
</tr>
</tbody>
</table>