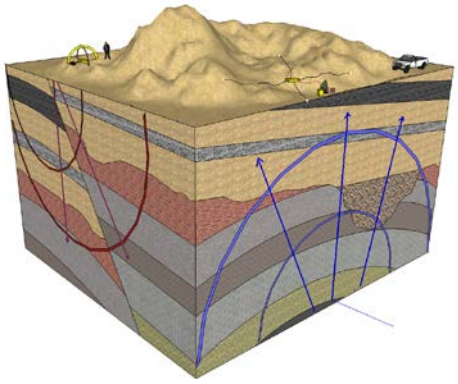
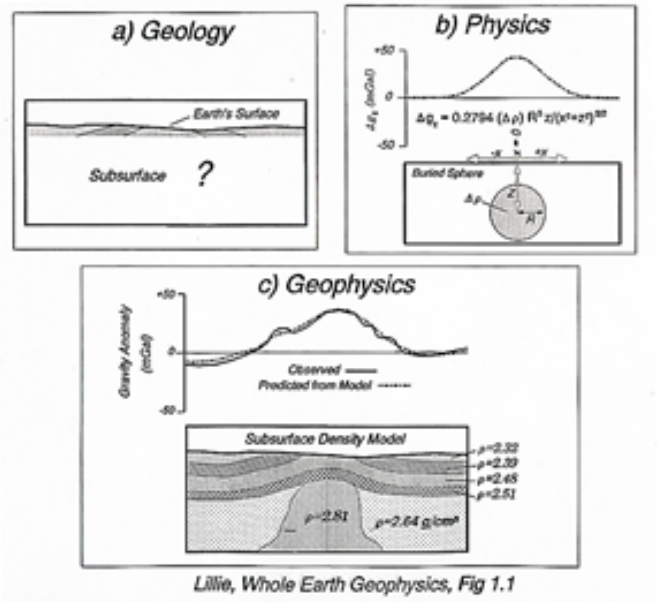
201 GPH
Unit 1 (Review)

Q. What is geophysics?

A. Geophysics is the science which deals with investigating the Earth, using the methods and techniques of Physics



Geophysics = Geological observations + Physical laws



Lillie, Whole Earth Geophysics, Fig 1.1

Q. What are the divisions of geophysics?

A. They are:

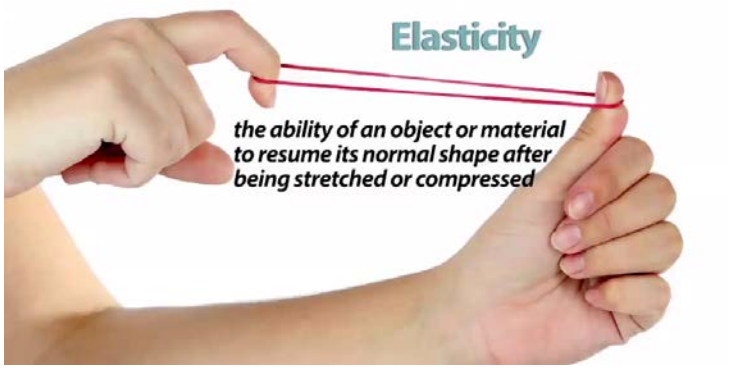
1. Global Geophysics: study earthquakes, magnetic field, physical oceanography, and meteorology.
2. Exploration Geophysics: Search for oil, gas, water, and minerals.

Q. What are the geophysical exploration methods?

A. They are:

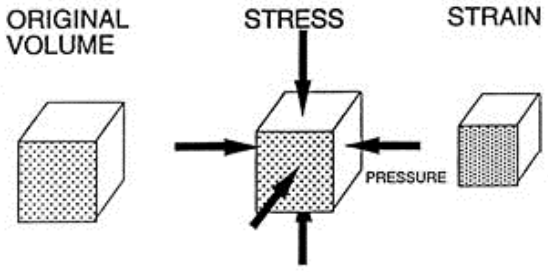
1. Passive Methods (Natural Sources): incorporates of natural occurring fields or properties of the Earth [i.e. Magnetotelluric, Telluric, Gravity, Magnetic].
2. Active (Induced Sources): a signal injected into the earth and then measure how the earth responds to the signal [i.e. Resistivity, Seismic Refraction, GPR].

Q. What is elasticity?



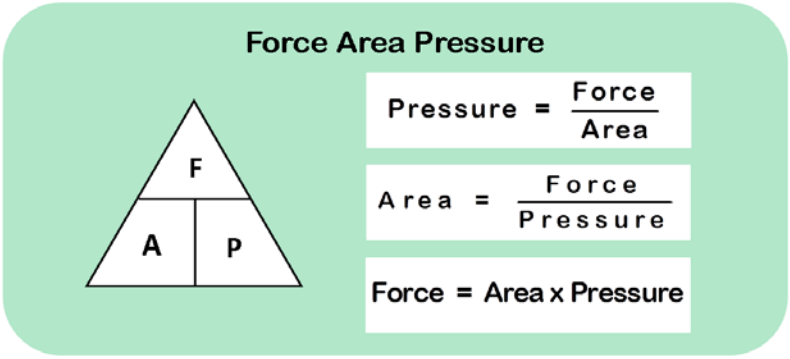
Q. What is the difference between stress and strain?

A. Stress: is the ratio of applied force F to the area across which it is acts. Strain: is the deformation caused in the body, and is expressed as the ratio of change in length (or volume) to the original length (or volume).



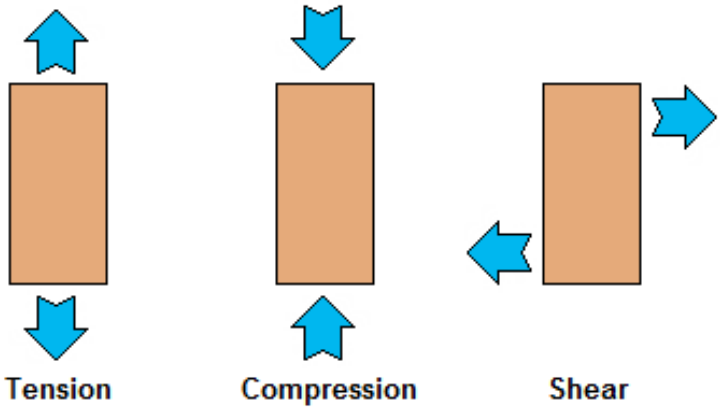
Q. What is pressure?

A. Pressure is the force applied perpendicular to the surface of an object per unit area over which that force is distributed.

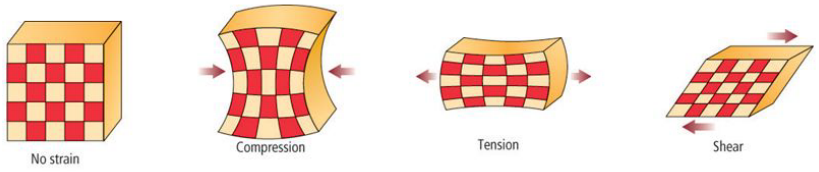


Q. What are types of stress?

A. Basically three different types of stresses can be identified. These are related to the nature of the deforming force applied on the body. That is, whether they are tensile, compressive or shearing.

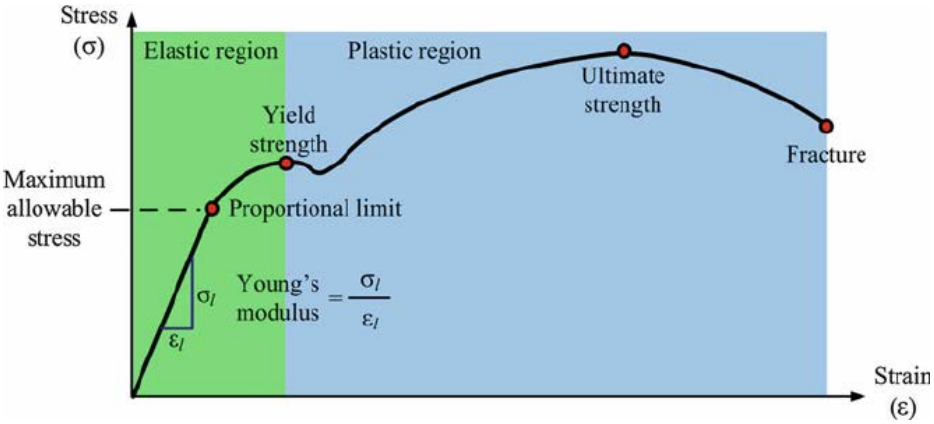


- **Compression** causes a material to shorten.
- **Tension** causes a material to lengthen.
- **Shear** causes distortion of a material.



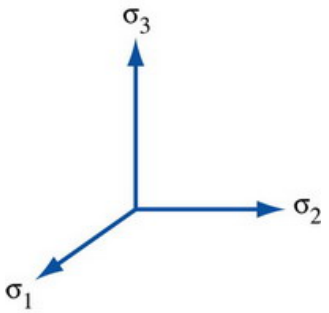
Q. What is stress-strain curve?

A. The relationship between the stress and strain that a particular material displays is known as that particular material's stress–strain curve.



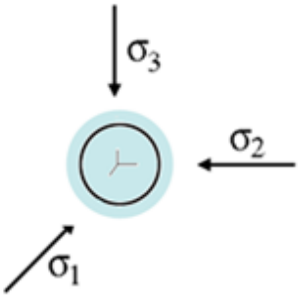
Q. What are the principle-stress axes?

A. Three mutually perpendicular axes (designated, σ1, σ2, and σ3) which are parallel to the directions of maximum, intermediate, and least principal stress. Their separate lengths and directions describe the state of stress at a particular point.



If all 3 principal stresses are equal (σ1 = σ2= σ3), the body is subjected to a pressure.

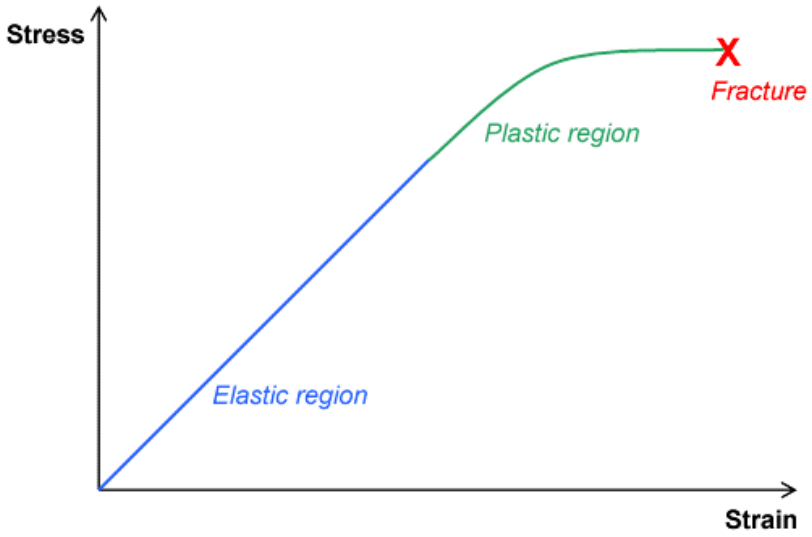
Pressure = sum of principal stresses/3



$\sigma_1 = \sigma_2 = \sigma_3$

Q. What is Hook's Law?

A. Hooke's Law essentially states that stress is proportional to strain.



Hooke's Law

- Hooke's law states that:

$$F \propto e$$

This is the force applied (N)

This is the extension (m)

Q. What are the elastic constants?

Elastic constants describes the strain of a material due to applied stress.

Modulus = stress/strain

The higher the value of the modulus, the stronger the material, the smaller the strain produced by a given stress.

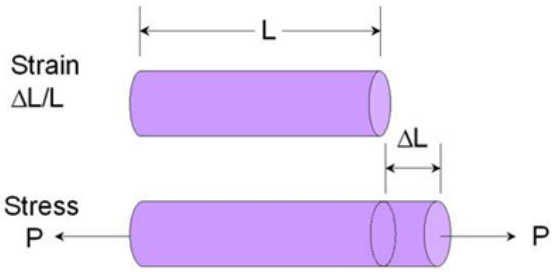
Elastic constants include:

- Young's Modulus — E
- Bulk Modulus — K
- Shear Modulus — μ
- Axial Modulus — ψ
- Poisson's Ratio — σ

Q. What is Young's modulus?

A. Young's modulus, also known as the elastic modulus, is a measure of the stiffness of a solid material

$$E = \frac{stress}{strain} = \frac{F/A}{\Delta l / l_o}$$



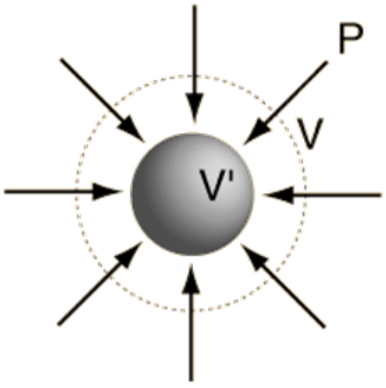
Q. What is Bulk modulus?

A. The bulk modulus is a measure of how incompressible/resistant to compressibility that substance is. It is defined as the ratio of the infinitesimal pressure increase to the resulting relative decrease of the volume

Bulk modulus:

$$B = \frac{\Delta P}{\Delta V / V}$$

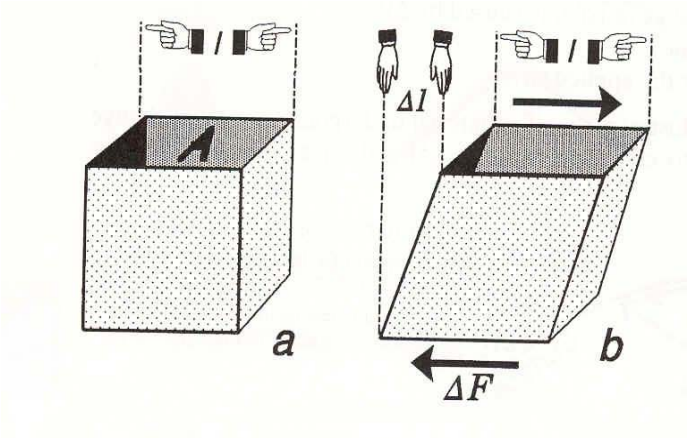
P = pressure
V = volume



Measure of the capacity of the material to be compressed. It can be carried out for solid, liquid, and gas.

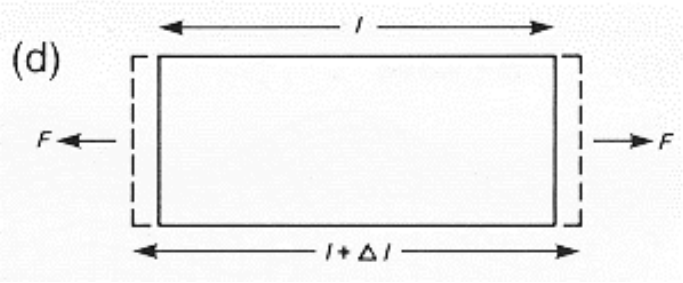
Q. What is Shear modulus?

A. It measure of the effort needed to change the shape of a material without change of volume (it is zero for liquid or gas).



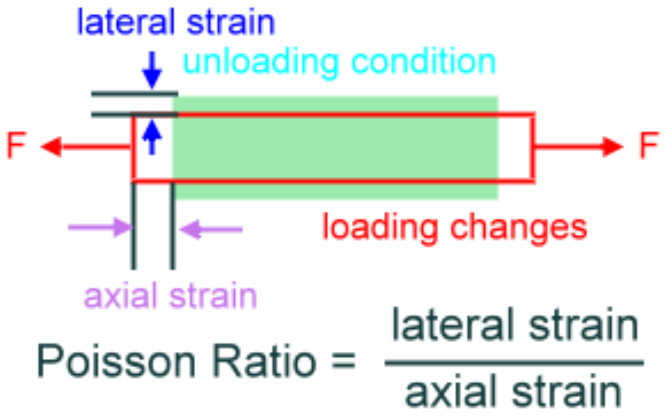
Q. What is axial modulus?

A. It is the ratio of longitudinal stress to uniaxial longitudinal strain.



Q. What is Poisson's Ratio?

A. It is the ratio of the proportional decrease in a lateral measurement to the proportional increase in length in a sample of material that is elastically stretched.



μ = shear modulus (as before)

λ = first Lamé coefficient (no direct physical interpretation)

Young's Modulus: $E = \mu(3\lambda + 2\mu) \div (\lambda + \mu)$

Bulk modulus: $K = \lambda + 2/3\,\mu$

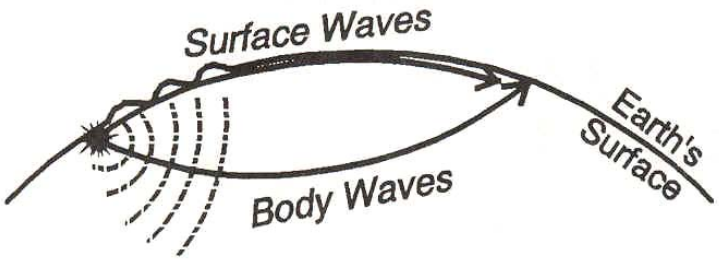
Poisson's Ratio: $\sigma = \lambda / 2(\lambda + \mu)$

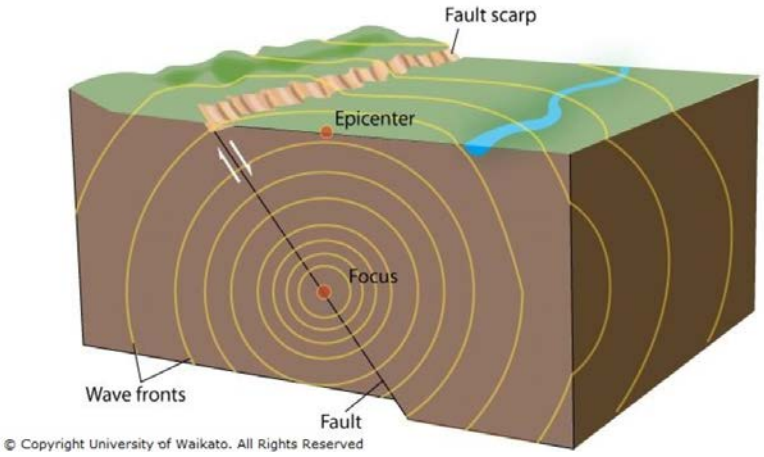
Lamé 1 in terms of Poisson & Young

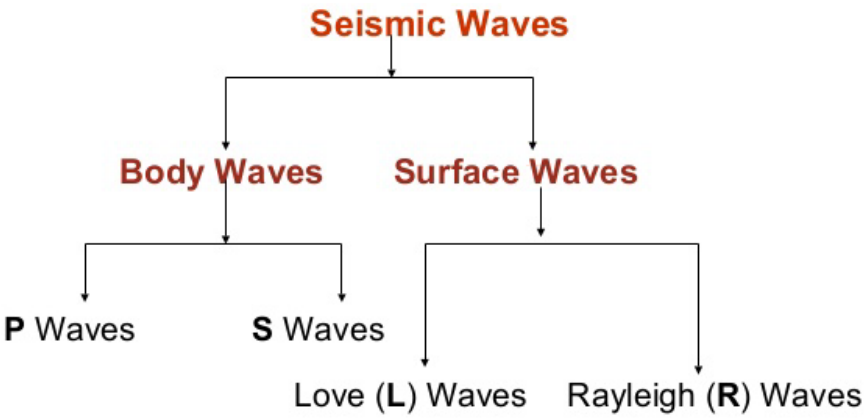
$\lambda = E\sigma / (1 + \sigma)(1 - 2\sigma)$

Q. What is seismic wave?

A. Seismic wave is an elastic wave in the earth produced by an earthquake or other means. Waves of energy that travel through the Earth's layers, and are a result of an earthquake, explosion, or a volcano.

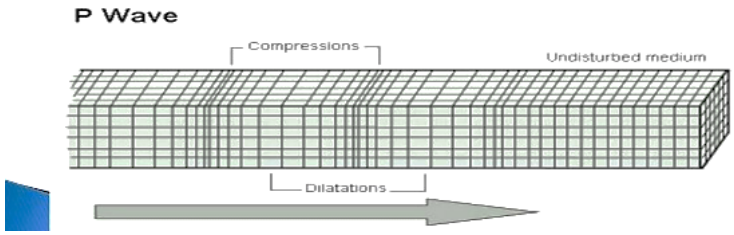






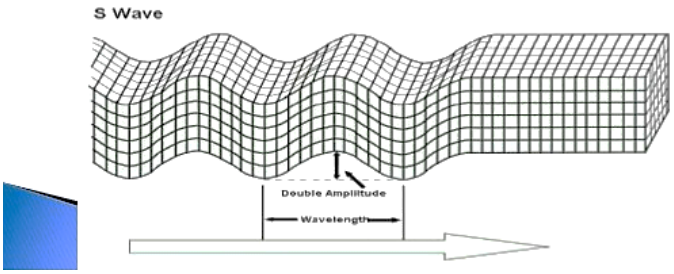
Body Waves

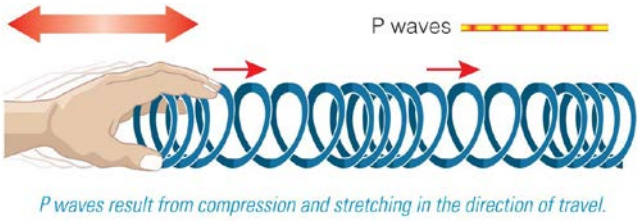
- **P Waves (compression wave)**
- The first kind of body wave is the **P wave** or **primary wave**. This is the fastest kind of seismic wave. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air.



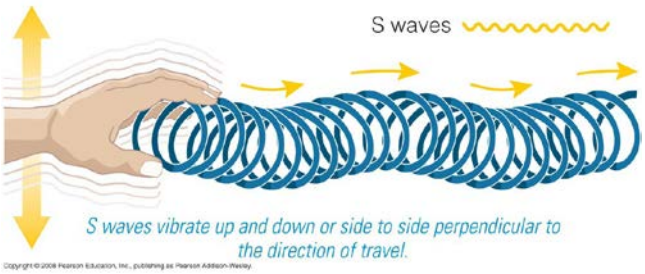
Body Waves

- **S wave (transverse wave)**
- The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock. This wave moves rock up and down, or side-to-side.



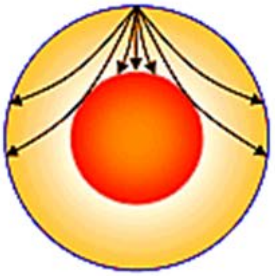


P waves result from compression and stretching in the direction of travel.

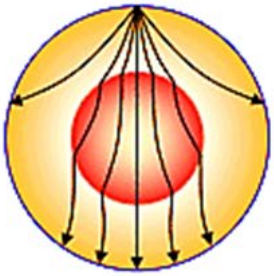


S waves vibrate up and down or side to side perpendicular to the direction of travel.

Q. What is the difference between P-wave and S-wave?



S waves
- transverse
- slow moving
- travel through solids only



P waves
- longitudinal
- fast moving
- travel through liquids and solids

Relationship between Vp and Vs

Compressional Waves

$$V_p = \sqrt{\frac{\left(\frac{4}{3}\mu + k\right)}{\rho}}$$

Shear Waves

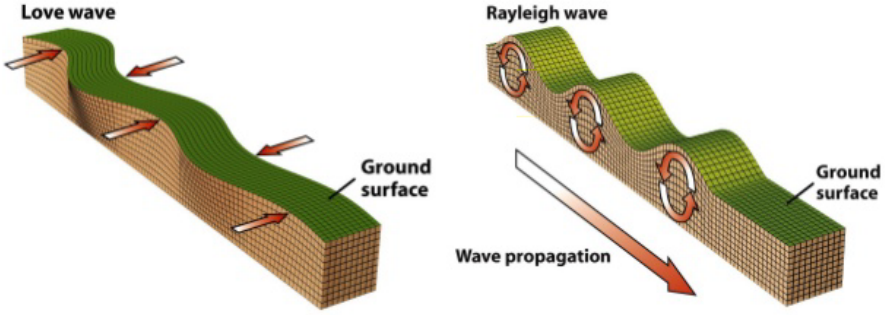
$$V_s = \sqrt{\frac{\mu}{\rho}}$$

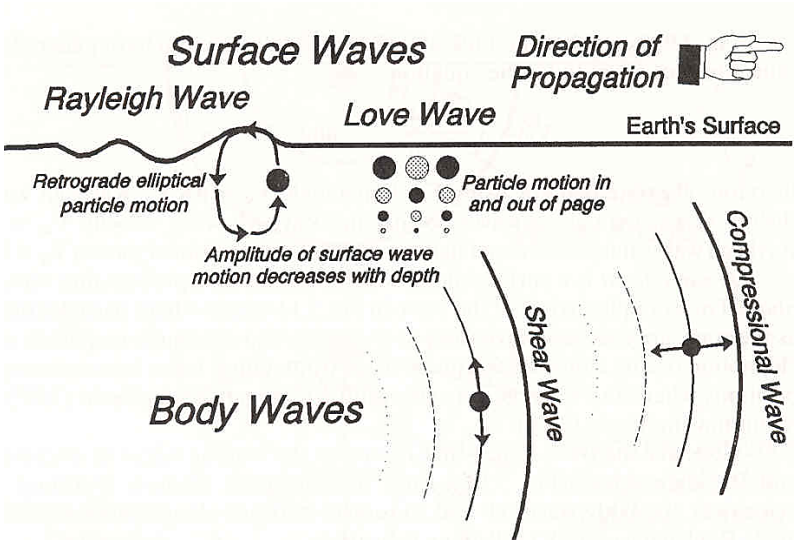
- Averaged Vp/Vs = 1.732 for the crust
- For mafic rocks, Vp/Vs = 1.81
- For felsic rocks, Vp/Vs = 1.70

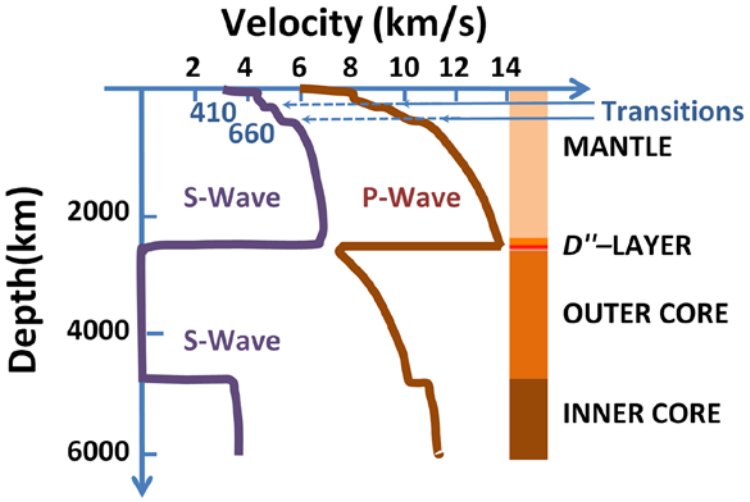
Surface waves- travel along Earth's surface

1. Love waves – S-waves that intersect the surface
   Back and forth motion
2. Rayleigh waves – P-waves at the surface
   move like ripples on a pond

These waves- slowest and more destructive

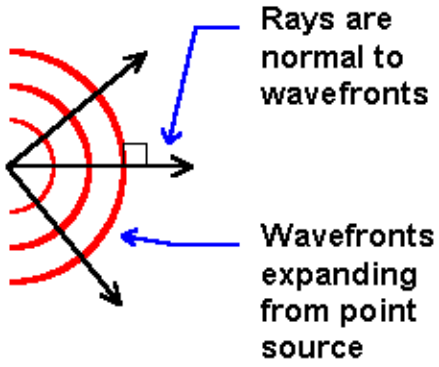




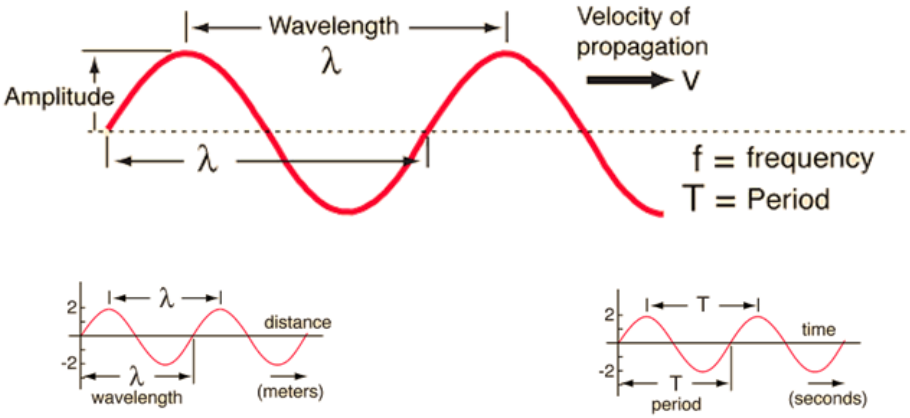


Q. What is the difference between wave front and ray path?

A. The wave front is the direct boundary between the seismic waves in the earth material, and the material that the seismic energy has not yet reached. Ray is the vector perpendicular to a wave front.



Q. What are the main parameters for a wave?

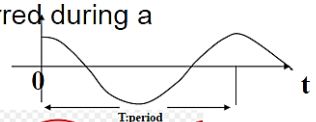


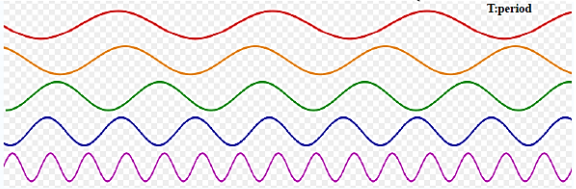
Wave Parameters

- Wave speed (v): unit: m/s; $V = x/t = \lambda/T$
- Wave period (T): unit: s

  Time needed from one peak to another successive peak.
- Frequency (f): unit: Hertz; f=1/T

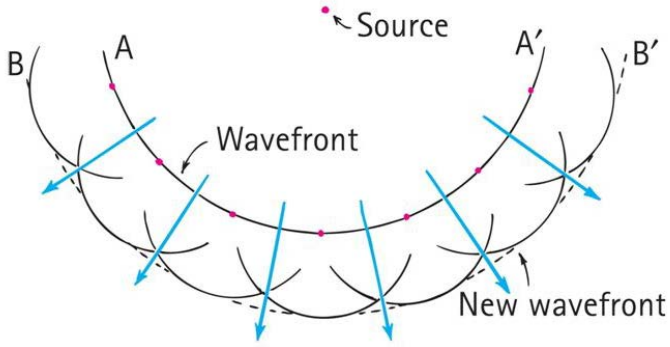
  Number of oscillations occurred during a standard interval of time
- Wave number: $K = 2\pi/\lambda$





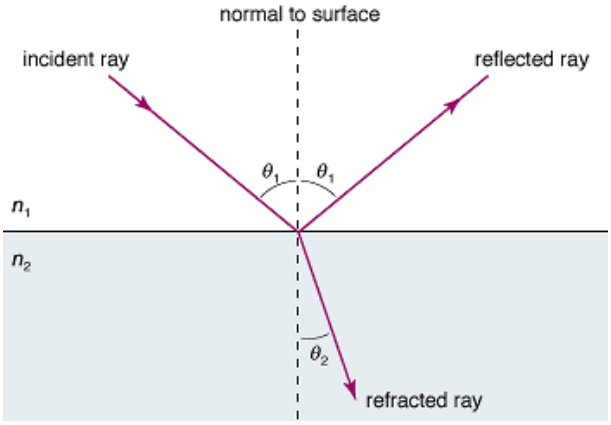
Q. What is Huygens's Principle?

A. He proposed that every point on a wave-front may be considered a source of secondary spherical wavelets which spread out in the forward direction at the speed of light



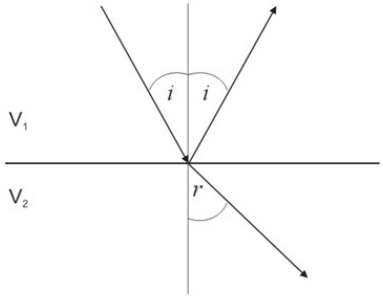
Q. What is Snell’s Law?

A. Snell's Law describes how elastic waves are reflected and refracted across a boundary separating layers of differing velocity.



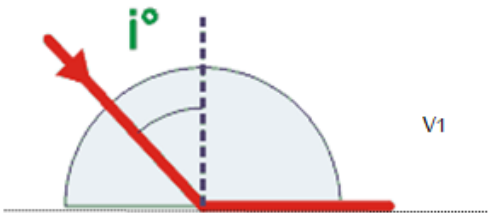
Snell’s Law

$$\frac{\sin i}{\sin r} = \frac{V_1}{V_2}$$

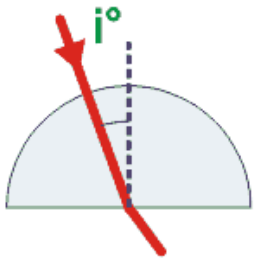


Q. What is the critical angle?

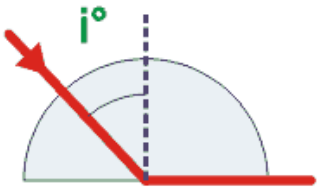
When V2 is greater than V1, the angle of refraction is greater than the angle of incidence, then the angle of incidence for which this occur us called the critical angle.



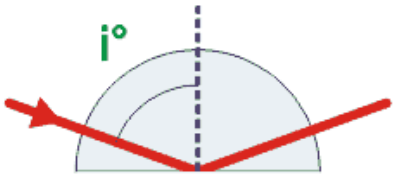
i° = Critical Angle



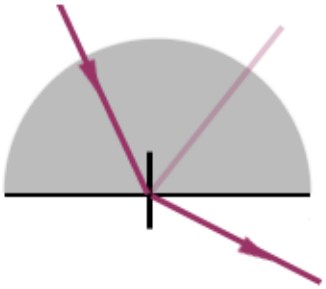
i° < Critical Angle



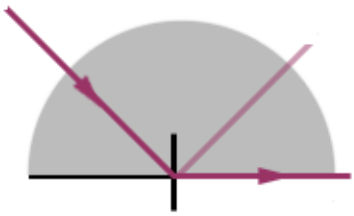
i° = Critical Angle



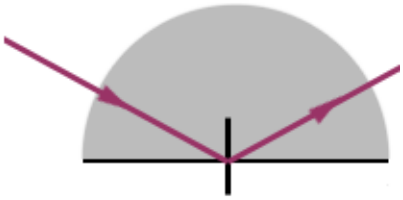
i° > Critical Angle



The angle of incidence is less than the critical angle.
Ray is refracted with a very small reflection.



The angle of incidence is equal to the critical angle.
Ray emerges along the edge of the block.



The angle of incidence is greater than the critical angle.
The ray is totally internally reflected.