Tutorial-01

Earthquake Engineering

1) Seismology is the study of Earthquakes and seismic waves that move through and around the earth.

2) Given data :-

Poisson's ratio (μ) = 0.25

$E = 1.2 \times 10^5$ MPa

$\rho = 5515$ kg/m^3

Difference in time of arrival between P and S waves,

Δt , Hyderabad = 90 sec

Delhi = 1.2 min = 1.2×60 sec = 72 sec

Mumbai = 30 sec

Velocity of P wave, $V_p = \sqrt{\frac{E(1-\mu)}{\rho(1-2\mu)(1+\mu)}}$

$\Rightarrow V_p = \sqrt{\frac{1.2\times10^5\times10^6(1-0.25)}{5515[1-2(0.25)](1+0.25)}} = 5109.8$ m/s $= 5.109$ km/s

$\boxed{V_p = 5.109 \text{ km/s}}$

Velocity of S wave, $V_s = \sqrt{\frac{E}{2\rho(1+\mu)}}$

$\Rightarrow V_s = \sqrt{\frac{1.2\times10^5\times10^6}{2\times5515(1+0.25)}} = 2950.17$ m/s $= 2.95$ km/s

$\boxed{V_s = 2.95 \text{ km/s}}$

3) P waves or Primary waves are compressional or longitudinal waves that push and pull the ground in the direction the wave is traveling. They usually cause very little damage.

S waves or Secondary waves travel more slowly than P waves. They travel in the same direction, but shake the ground back and forth perpendicular to the direction the wave is traveling.

S waves are more dangerous than P waves because they have greater amplitude and produce vertical and horizontal motion of the ground surface.

4). Gondwana, an ancient super continent that incorporated present day South America, Africa, Arabia, Madagascar, India, Australia and Antarctica.

- It was fully assembled by Late Precambrian time, (some 600 million years ago) and the first stage of its breakup began in the Early Jurassic period (about 180 million years ago).

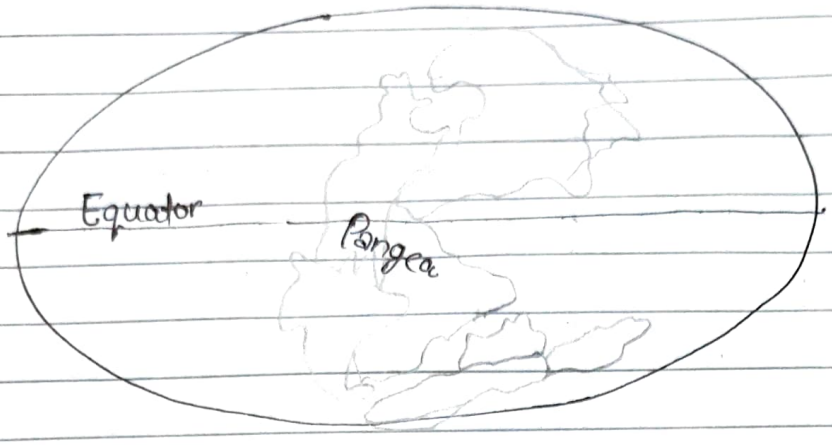
- The western half of Gondwana (Africa and South America) separated from the eastern half (Madagascar, India, Australia and Antarctica).

- The south Atlantic ocean opened about 140 million years ago as Africa separated from South America.

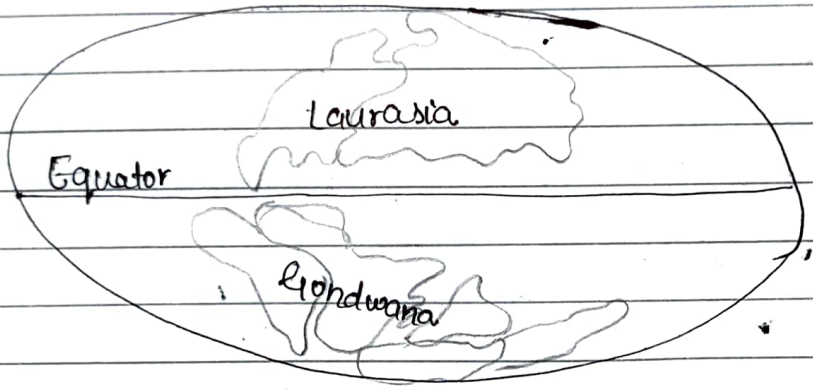
- At about the same time, India, which was still attached to Madagascar, separated from Antarctica and Australia.
- India eventually collided with Eurasia (Some 50 million years ago), forming Himalayan mountains.

- While the northward-moving Australian plates had just begun its collision along the Southern margin of Southeast Asia - a collision that is still underway today.

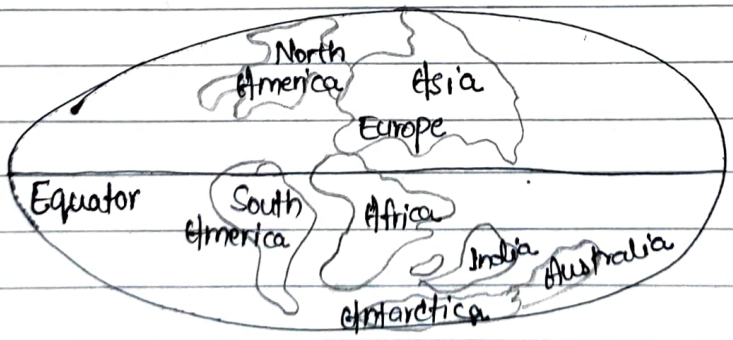
4)



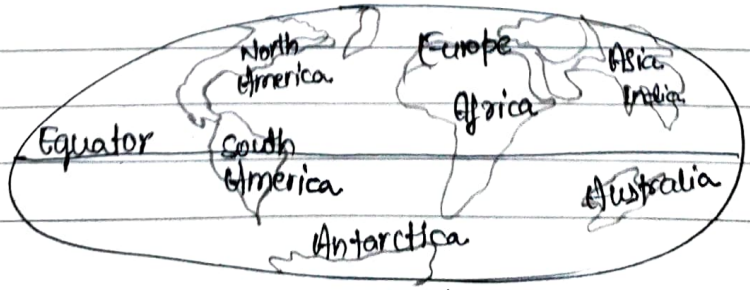
225 million years ago



150 million years ago



100 million years ago



Earth today

5) Different layers of earth's structure are -

- Crust
- Mantle
- Core

a) CRUST - i) It is the outermost solid part of the earth.

ii) The thickness of the crust varies under the oceanic and continental areas.

iii) Oceanic crust is thinner as compared to the continental crust.

iv) Silica (Si) and Aluminium (Al) are major constituent minerals. Hence it is termed as SIAL. SIAL is also used to refer Lithosphere.

b) MANTLE - i) The portion of the interior beyond the crust is called the mantle.

ii) It is in solid-state.

iii) It has a density higher than the crust portion.

iv) The major constituent elements of the mantle are Silicon and Magnesium and hence it is also termed as SIMA.

c) CORE - i) The core-mantle boundary is positioned at the depth of 2,900 Km

ii) The inner core is in the solid-state whereas the outer core is in the liquid state.

iii) The core is made up of very heavy material mostly constituted by nickel and iron. Hence it is also called as "nife" layer

Mechanical layers of mantle -

- Lithosphere
- Asthenosphere
- Mesosphere

i) Lithosphere - It is the rigid, outermost layer of the Earth's rocks and minerals which consists of the crust and upper mantle.

- The lithosphere is broken into tectonic plates. These plates are always in motion, though the motion is so slow, it is undetectable to humans.

- The chemical composition of the lithosphere varies from place to place on earth.

- Some of the elements that make up the majority of the lithosphere are silicon, iron and magnesium with other elements like aluminum, sodium and potassium also present.

ii) Asthenosphere - It is a part of the upper mantle just below the lithosphere

- It is a layer of solid rock where the extreme pressure and heat cause the rocks to flow like a liquid.

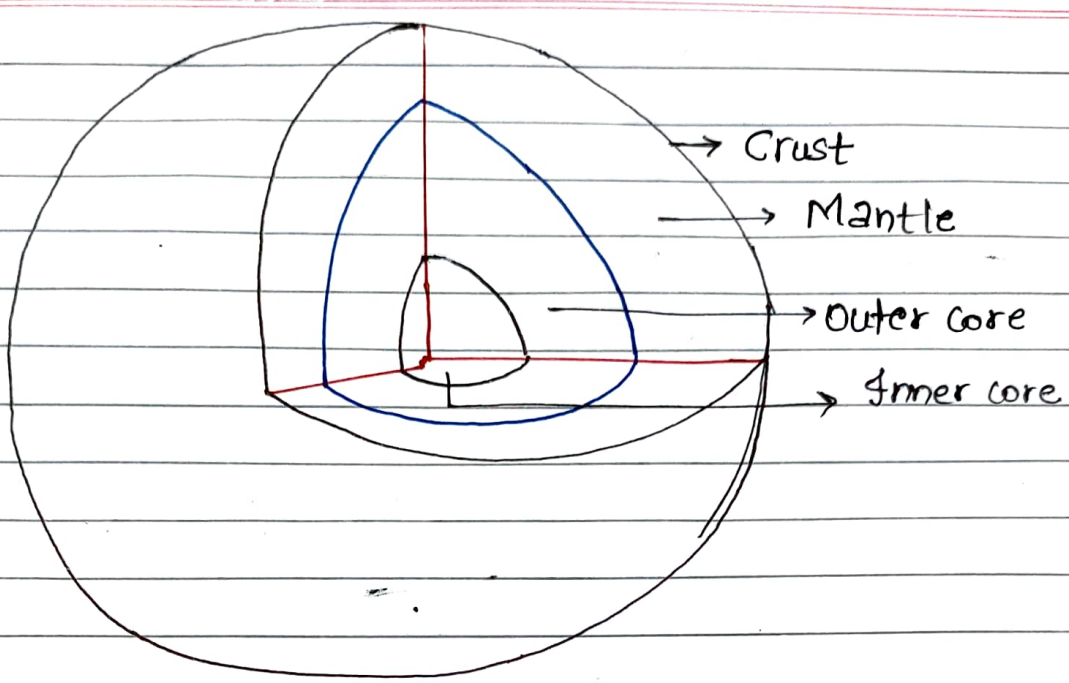
- The rocks in the asthenosphere are not as dense as the rocks in the lithosphere.

- This allows the tectonic plates in the lithosphere to move around on the Earth's surface.

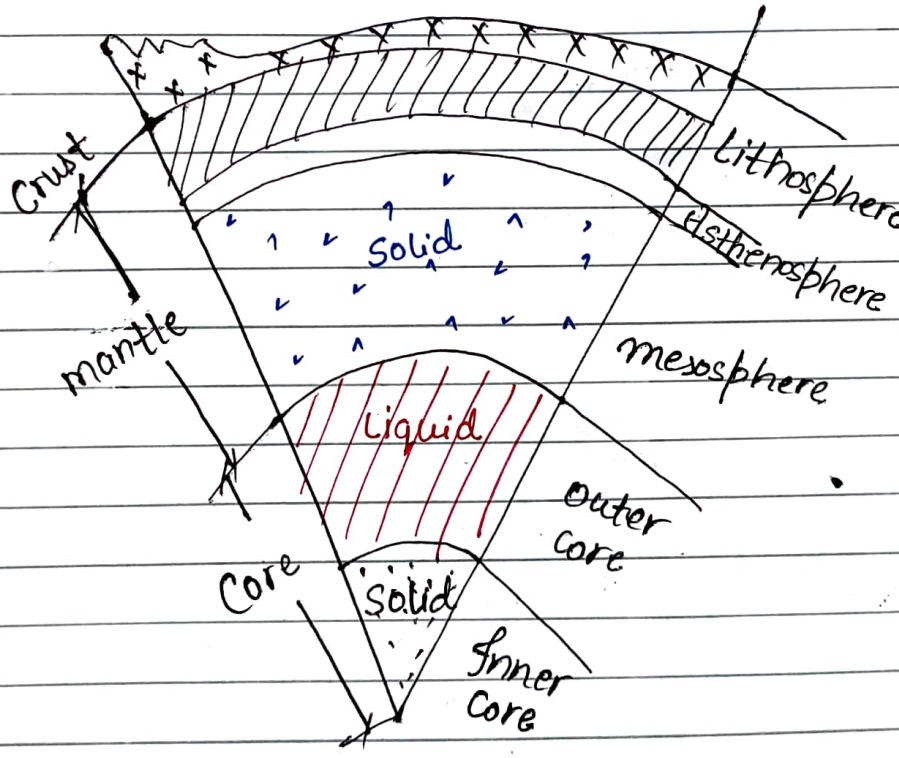
iii) Mesosphere -

- Mesosphere, region of the upper atmosphere between about 50 and 80 km (30 and 50 miles) above the surface of the Earth.

- The base of the mesosphere is defined as the temperature maximum existing at the top of the stratosphere, with the boundary between the two regions usually called the Stratopause.
- The mesosphere extends upward to the next temperature minimum, which defines the base of the thermosphere, the boundary between the two regions is called the mesopause.



Different layers of earth's structure



Mechanical layer's

6) Different types of faults are -

- Normal fault
- Reverse (thrust) fault
- Strike - slip fault

- Normal fault - A dip-slip fault in which the upper block, above the fault plane, moves up and over the lower block.
- It is produced by vertical compression as Earth's crust lengthens.
- The hanging wall slides down relative to the footwall.

- They are common, they bound many of the mountain ranges of the world and many of the rift valleys found along spreading margins.

- Reverse fault - In a reverse fault, the block above the fault moves up relative to the block below the fault.

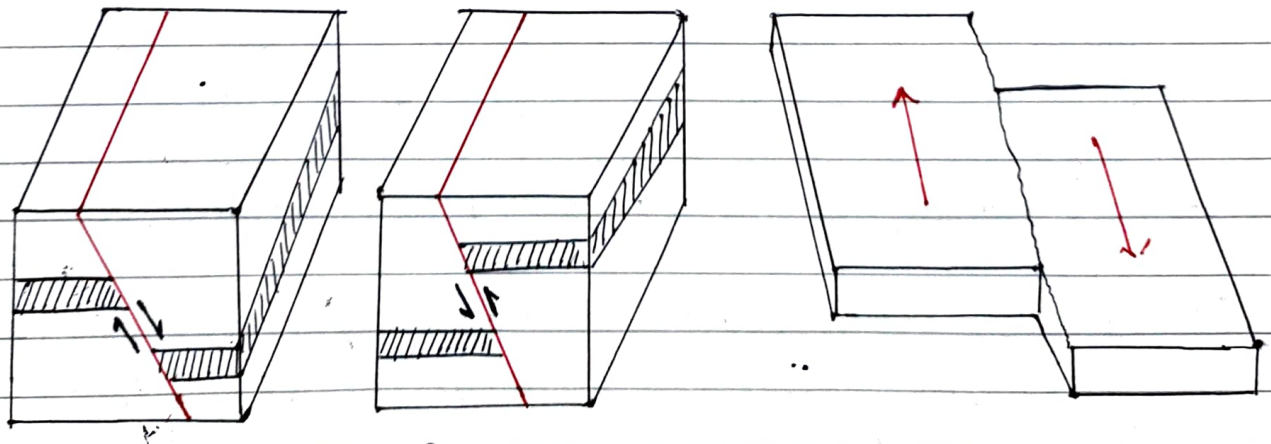
- This fault motion is caused by compressional forces and results in shortening.

- A reverse fault is called as thrust fault if the dip of the fault plane is small.
  ex. - Rocky mountains, Himalayas.

- Strike slip fault -

  Strike slip fault, a fracture in the rocks of Earth's crust in which the rock masses slip past one another parallel to the strike, the intersection of a rock surface with the surface or another horizontal plane.

- These faults are widespread, and many are found at the boundary between obliquely converging oceanic and continental tectonic plates.



Normal fault Reverse fault Strike - slip fault

7) Classification of Earthquake based on Location -

Inter plate	Intraplate
An interplate earthquake is one that occurs at a plate boundary.	An intraplate earthquake is an earthquake that occurs in the interior of a tectonic plate.
Recurrence time is less.	Recurrence time is longer
Interplate earthquakes are recognized at surface.	Intraplate earthquake are rarely recognized at surface because faults are buried under several Kms of surface materials and longer recurrence intervals allow any surface expression of faulting to be eroded

Based on focal length -

Shallow Earthquake	Deep Earthquake
Shallow-focus earthquakes occur at depths less than 70 Km	Deep-focus earthquakes occur at greater focal depths of 300-700 Km
Shallow focus earthquakes are found within the earth's outer crustal layer.	Deep focus earthquakes occur within the deeper subduction zones of the earth.
These earthquakes are of smaller magnitudes, of the range 1 to 5.	These earthquakes are of higher magnitudes, 6 to 8 or more.
Less energy is released during a shallow focus earthquakes.	Tremendous energy accumulates during a deep focus earthquakes.

Based on the cause -

Non-tectonic Earthquakes - These are due to volcanic activities and man-made reasons. e.g.- nuclear testing, blasts, construction of dams etc.

Tectonic Earthquakes - These are due to sudden slip in the fault of the tectonic plates of the earth.

Based on the magnitude of the earthquake -

Class	Magnitude
Great	8 or more
Major	7 - 7.9
Strong	6 - 6.9
Moderate	5 - 5.9
Light	4 - 4.9
Minor	3 - 3.9

8) a) Rings of Fire - It is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes.

- Its length is approximately 40,000 kms.
- It traces boundaries between several tectonic plates - including the Pacific, Juan de Fuca, Cocos, Indian-Australian, Nazca, North America, and Philippine plates.
- 75% of Earth's volcanoes - more than 450 volcanoes are located along the Ring of Fire.
- 90% of Earth's earthquakes occur along its path, including the planet's most seismic events.

- The abundance of volcanoes and earthquakes along the Ring of Fire is caused by the amount of movement of tectonic plates in the area.

b) Convective currents-

- The plates that make up the Earth's crust are continually moving at around 2-3 cm per year.
- The disturbance of the continents today is very different to what they were millions of years ago.
- This is because the plates have moved as the result of convection currents in the mantle
- Convection currents drive the movement of Earth's rigid tectonic plates in the platehet's fluid molten mantle.
- In places where convection currents rise up towards the crust's surface, tectonic plates move away from each other in a process of seafloor spreading.