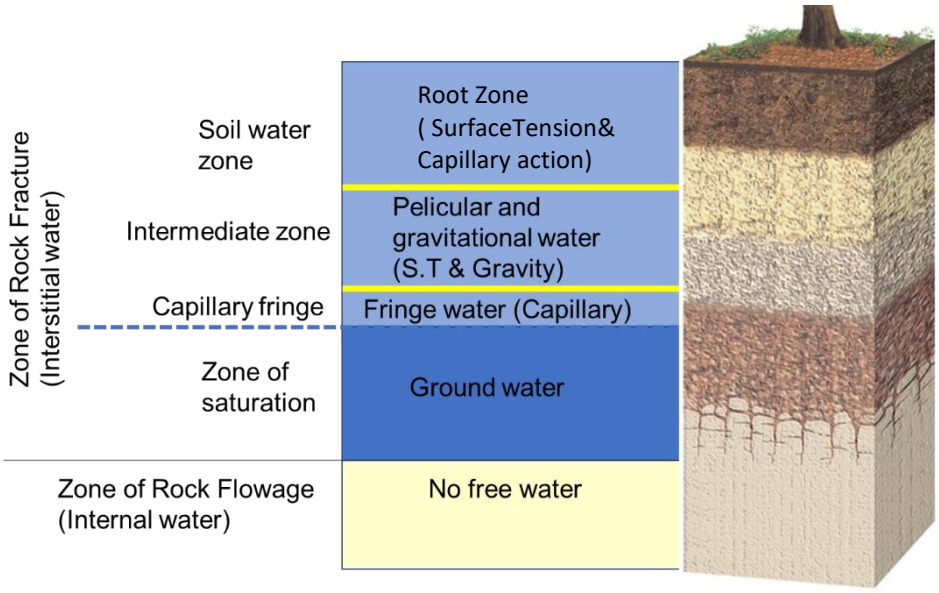
Monsoon Semester Examination 2021-22
Sub: Earth Science Modular (GLI101)
Total Marks: 100

1. Elaborate on the following with neatly drawn and labelled diagrams wherever necessary
   a) The vertical distribution of groundwater along with its important components. [**10 marks]**
   b) Discuss the various parameters of water quality assessment. [**10 marks]**

Ans Key:

1(a)



[4 marks]

Zone of rock fracture and zone of rock flowage **(1 mark)**

Zone of aeration and zone of saturation **(2 marks)**

Soil water zone, intermediate zone, capillary fringe - processes involved and forces acting **(2 marks)**

Water table **(1 mark)**

(b) TDS along with its correlation with electrical conductivity and refractive index **(2.5 marks)**

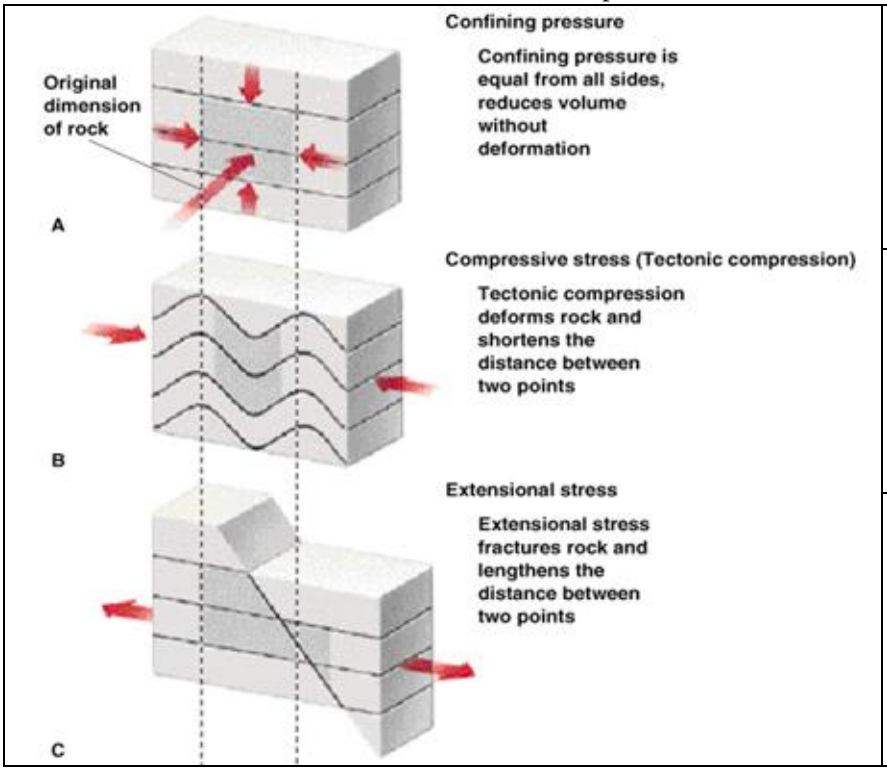
Salinity – definition and scale **(2.5 marks)**

Hardness- definition and formula **(2.5 marks)**

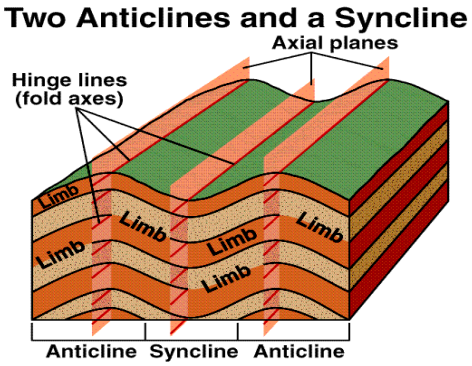
Acidity, Alkalinity and pH **(2.5 marks)**

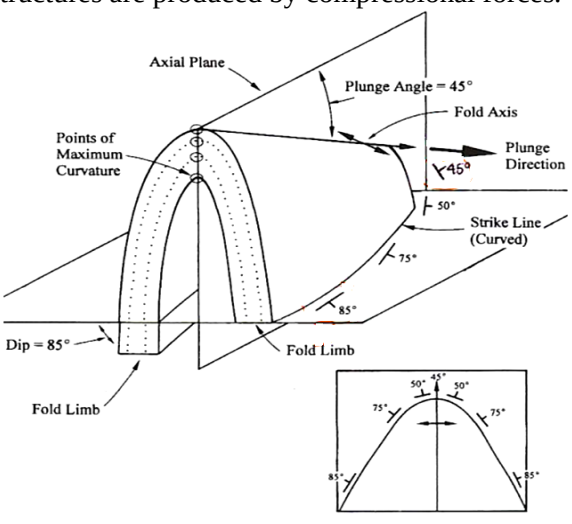
Q 2. (a) Draw the labelled diagrams of different types of deformational structures in rocks formed by compressional and extensional stress. [8 marks]

Ans: Deformational structures like **folding, faulting and joints** are developed in rocks due to the compressional and extensional/tensional stress acting on them. Depending on the direction of the stress, a definite deformational structure is developed.

<table>
<tr>
<td rowspan="3"> 
</td>
<td>Stress applied on a strata triggers the process of deformation</td>
</tr>
<tr>
<td>Folding produced by compressional forces acting on the strata</td>
</tr>
<tr>
<td>Tensional/extensional forces results failure in the form of fracture and faulting which dislocates/displace the rock horizon</td>
</tr>
</table>

<u>Folding</u>: The bending or crumbling of rock-strata due to compressional forces acting tangentially or horizontally towards a common point or plane or rather shortening from opposite directions is known as folding. Anticlines, synclinses, dome and basin structures are produced by compressional forces.

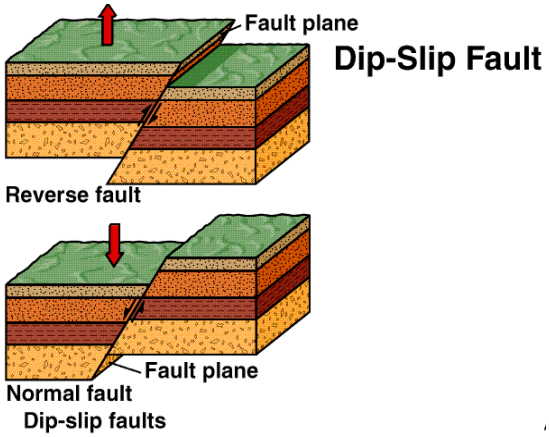


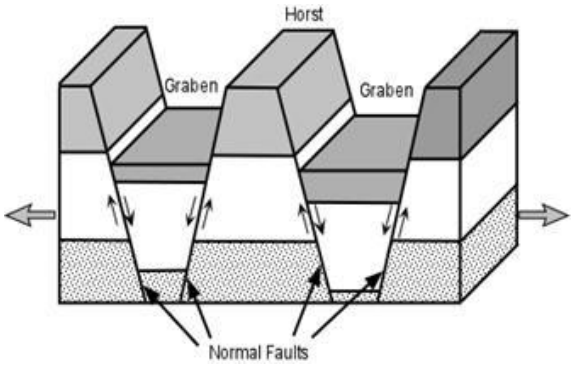


Joints and varieties of faults are produced either due to compression or extension/tension in rocks.

On the basis of the apparent movement of blocks fault have the following types

1. **Normal fault**: Normal fault is one in which the hanging wall *falls down* relative to the foot wall due to **tensional stress**. These are observed in divergence setting.
2. **Reverse fault**: Reverse fault is one in which the hanging wall *moves up* relative to the foot wall due to **compression**.
3. **Thrust**: If the hanging wall is pushed *up and then over* the foot wall at a low angle (<45 degrees) it is called a thrust fault.

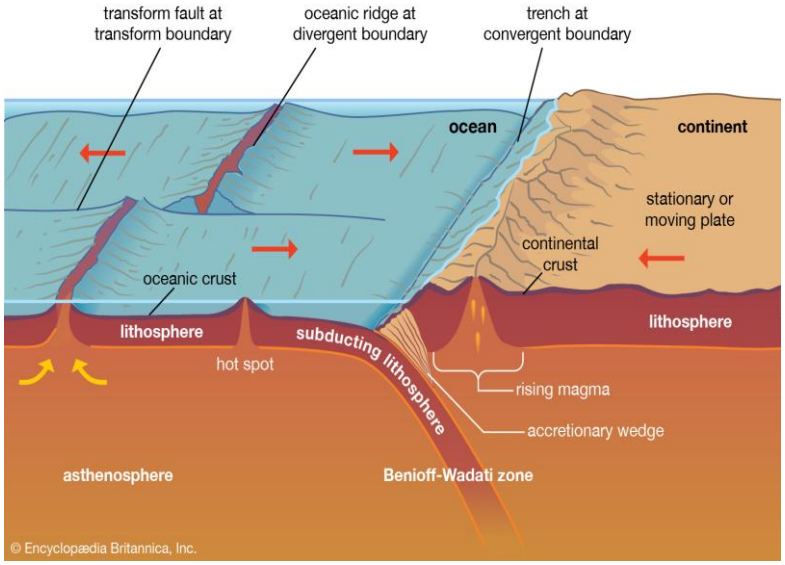




(b) Define ocean floor spreading and discuss the mechanism with suitable diagrammatic expressions and examples. [6 marks]

Ocean floor/Sea floor spreading is the process of formation a new oceanic crust along the divergent plate boundary or the rift margin. Once, the ocean floor is developed, it again dives into the asthenopshere along the subduction zone similar to a conveyer belt. The different stages for ocean floor spreading are

i) Mantle convection leading, rise of the magma along the thinner lithosphere
ii) Eruption of basaltic magma along the rift/divergence zone to produce a new oceanic crust
iii) Widening of the basin and formation of a ocean/sea



(c) Name 3 types of major economically mineable metallic mineral resources from the states of i) Jharkhand; ii) Karnataka, iii) Rajasthan; iv) Odisha [6 marks]

Ans: The economically mineable metallic minerals include the metallic ore deposits where mining is going on or concentrated in substantial quantity. **(Coal, mica, gypsum, barite, graphite, dolomite, asbestos, gemstones, building stones etc. do not come under the metallic mineral category)**

i. **Jharkhand:** Iron ore (hematite/magnetite), Manganese Ore, Bauxite ore, Uranium ore and Copper Ore. **[0.5 x 3 =1.5 marks]**
ii. **Karnataka:** Iron, Manganese, Gold, Copper, chromite **[0.5 x 3 =1.5 marks]**
iii. **Rajasthan:** Lead Ore (Galena), Zn Ore (Sphalerite), Cu-ore, Tungsten ore, Gold **[0.5 x 3 =1.5 marks]**
iv. **Odisha:** Iron, manganese, bauxite, chromite, ilmenite, copper, Pb-Zn **[0.5 x 3 =1.5 marks]**

Q3. Answer all parts (5x4=20 marks)

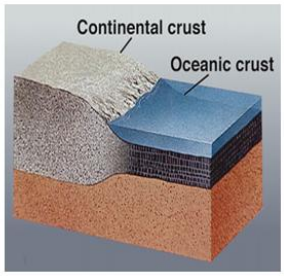
Instructions: Read all instructions carefully mentioned in each question. Detailed answers are not required, write to the point.

a. What is the density of crust and mantle (mentioning the unit of density is a must)? What are the two types of crust? Write onlytwo lines mentioning about the composition and density of both types of crust (2+3 marks)

Ans. Density of crust (2.7 g/cm^3) and mantle (3.3 /cm^3) (2 marks)
Two types of crust are oceanic and continental. Oceanic crust is of basalt composition and continental crust of granite composition. Oceanic crust is more dense than continental crust (3 marks)

The Crust

- Outer layer: we step on it!
- 5-100 km thick
- 2 types of crust
  - Oceanic (very dense, made of basalt)
  - Continental (less dense, made of granite)

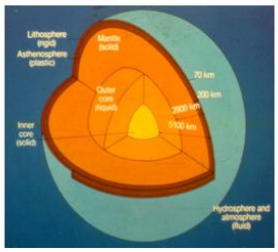


b. Draw the physical structure of the Earth and label all the layers in the diagram properly (5 marks) (Only properly labelled diagram is required in this question).

Ans. Diagram with proper labelling of all five layers. One mark for marking each layer correctly.

Physical Structure of the Earth
(5 Layers)

- Lithosphere- rigid outer layer (crust + upper mantle)
- Asthenosphere- solid rock that flows slowly (like hot asphalt)
- Mesosphere- middle layer (lower mantle)
- Outer Core- liquid layer
- Inner Core- solid, very dense



c. Name all types of Meteorites. Mention the most significant characteristic ofevery type of meteorite (paragraphs are not required, one lineeach for all types of meteorites) (1+4 marks).

Ans. Four main types of meteorites (1mark)

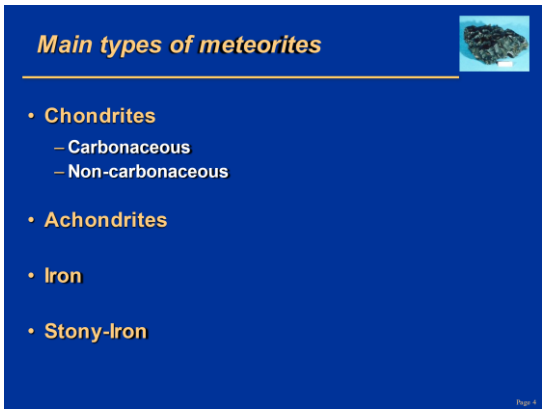
1) Chondrites
2) Iron
3) Stony-Iron
4) Achondrites

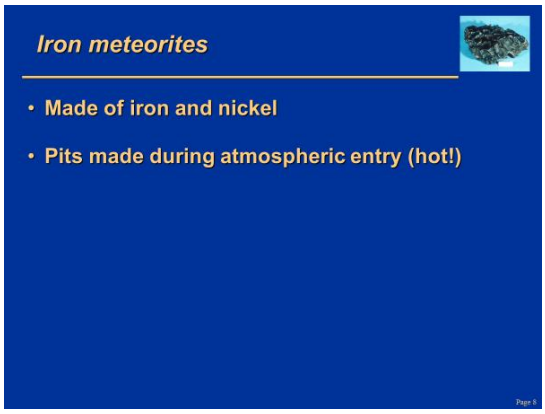
Chondrites are rocky, inhomogeneous meteorites containing round "chondrules" (1 mark)

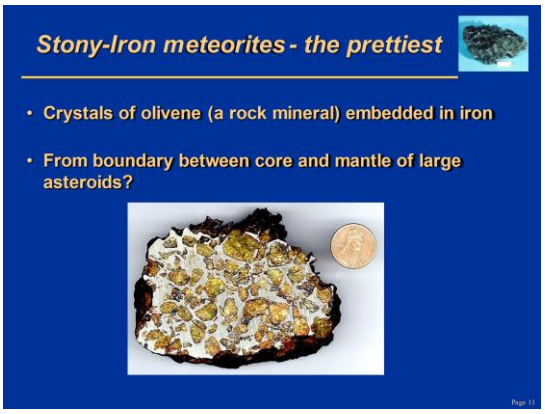
Iron meteorites contain differentiated core of Fe and Ni (1 mark)

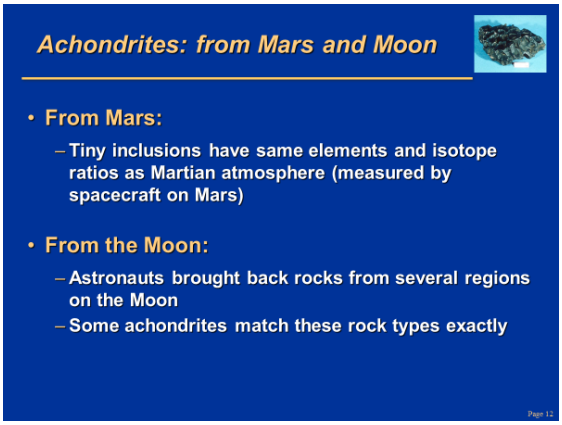
Stony-iron meteorites contain crystals of olivine embedded in iron (1 mark)

Achondrite meteorites are from Mars and Moon (1 mark)









d. How are terrestrial planets different from Jovian planets, giveany two characteristics? Besides, planets what other small bodies orbit around sun, mention theirmost significant characteristics(one line each for all types of small bodies)(2+3 marks).

Ans: Any two differentiating characteristics (2 marks)

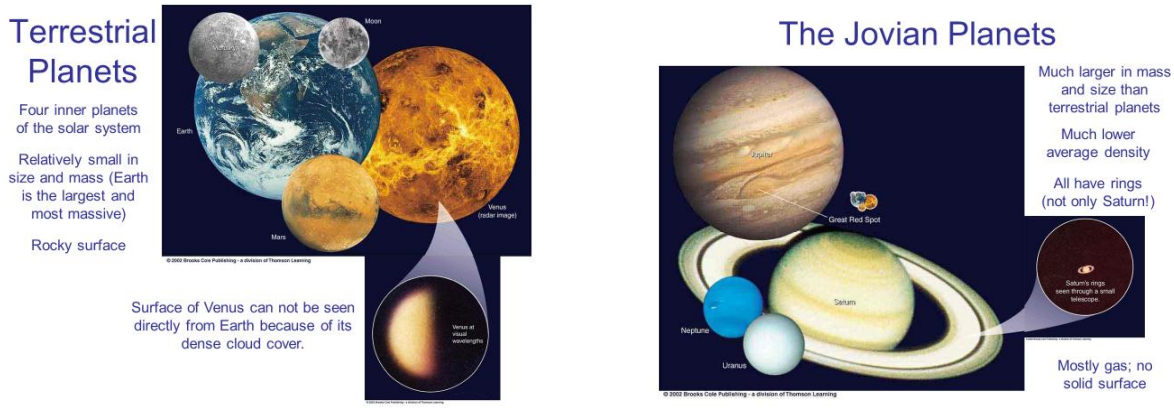
1. Terrestrial planets are relatively small in size and mass
2. Presence of rocky surface in terrestrial planets
3. Presence of craters in terrestrial planets
4. Much lower average density in Jovian planets
5. Jovian planets are made up of mostly gas

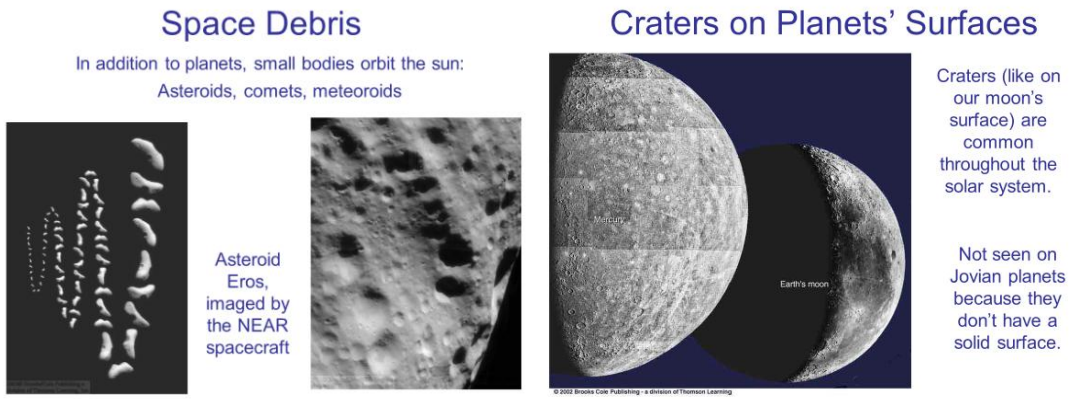
Small bodies orbiting around the sun: Comets, Asteroids and Meteoroids (3 marks)

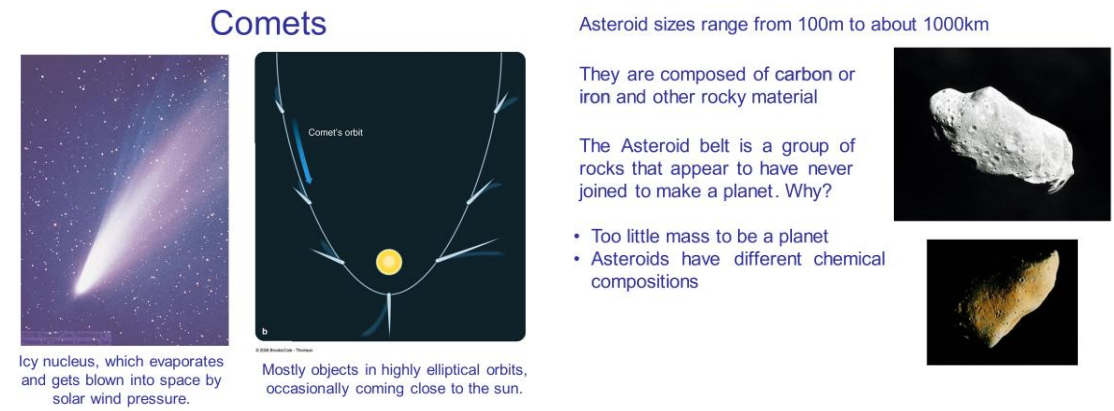
Comets contain icy nucleus, which evaporates and gets blown into space by solar wind pressure

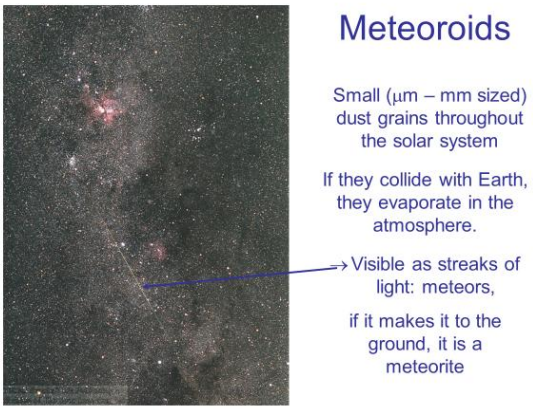
Asteroid are small bodies ranging in size from 100m to about 1000kmand composed of carbon or iron and other rocky material

Meteoroids are small (micron – mm sized) dust grains throughout the solar system, visible as streaks









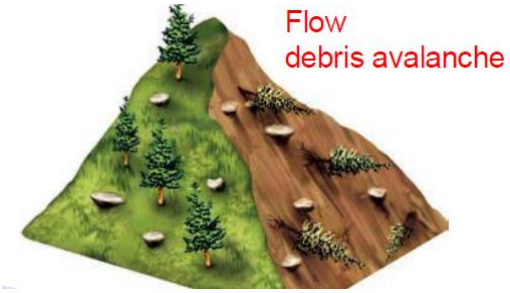
Q. No. 4 a. How do you differentiate Slide, Slump, avalanche and subsidence? Explain with neat sketches. [10 Marks]

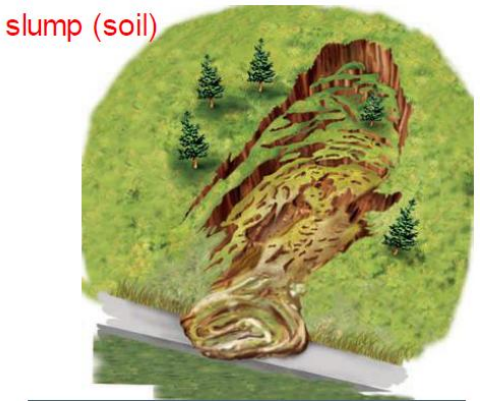
Answer: All these are resultant due to mass movement/ mass wasting phenomena

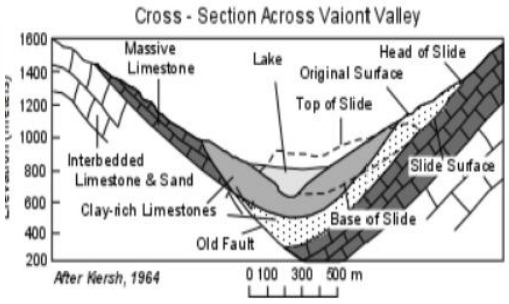
- **Slide:** A natural disaster that involves the breakup and downhill flow of rock, mud, water and anything caught in the path.
- **Subsidence:** A sinking of something to a lower level, especially of part of the surface of the Earth due to underground excavation or seismic activity or groundwater depletion.
- **Slump:** Slumping allows the materials to fall downward along a curved plane.
- **Avalanche:** It is the movement of a large mass of ice or snow down a sloppy terrain. The movement of debris or rocks down a slope in a similar manner is also known as avalanches and they are called as debris avalanche. An avalanche is triggered by the interaction between the terrain, weather, and the snow.

What is the difference between a slide and a slump? Sliding allows the materials to fall downward in an inclined plane, whereas slumping allows the materials to fall downward along a curved plane. Slumps and slides are downslope movements of sediments above a shear surface. Landslides involve rock and debris moving downslope along a planar surface, whereas slumping usually occurs along a curved interface and as a single large unit.

Slides: rockslide and slump (soil) Both are in contact with the surface below. They generally move as coherent units.
Whereas avalanche occur due to non-coherent, chaotic movement and some extent subsidence also somewhat chaotic and moves down or laterally as en mass.







Subsidence

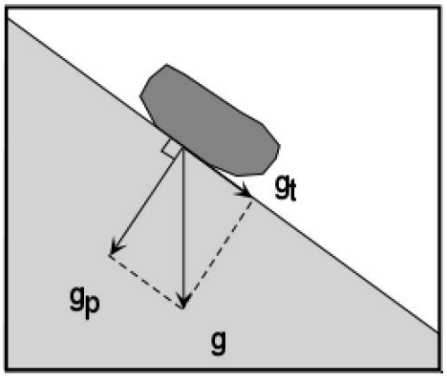
Q. No. 4b. Explain the factors that influence slope stability on the slide potential and concept of angle of repose with neat sketches and formulae. [10 Marks]

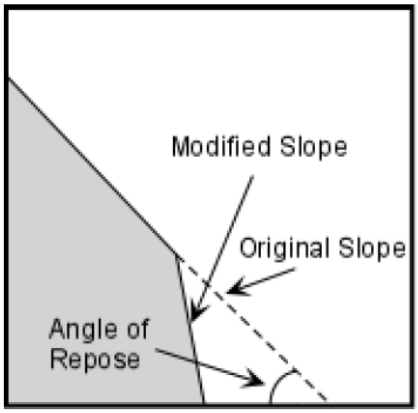
Answer: Factors that Influence Slope Stability

Gravity

The main force responsible for mass wasting is gravity. Gravity is the force that acts everywhere on the Earth's surface, pulling everything in a direction toward the center of the Earth. On a steeper slope, the shear stress or tangential component of gravity, gt, increases, and the perpendicular component of gravity, gp, decreases. The forces resisting movement down the slope are grouped under the term shear strength which includes frictional resistance and cohesion among the particles that make up the object.

When the sheer stress becomes greater than the combination of forces holding the object on the slope, the object will move down-slope.





Thus, down-slope movement is favored by steeper slope angles which increase the shear stress, and anything that reduces the shear strength, such as lowering the cohesion among factor, Fs, the ratio of shear strength to shear stress.

Fs = Shear Strength/Shear Stress.

If the safety factor becomes less than 1.0, slope failure is expected.

Role of Water

Water plays an important role in aiding slide potential

Angle of Repose:

Dry unconsolidated grains will form a pile with a slope angle determined by the angle of repose. The angle of repose is the steepest angle at which a pile of unconsolidated grains remains stable, and is

controlled by the frictional contact between the grains. In general, for dry materials the angle of repose increases with increasing grain size, but usually lies between about 30 and 37°. Slightly wet unconsolidated materials exhibit a very high angle of repose because surface tension between the water and the solid grains tends to hold the grains in place.

When the material becomes saturated with water, the angle of repose is reduced to very small values and the material tends to flow like a fluid. This is because the water gets between the grains and eliminates grain to grain frictional contact.

Liquefaction

Expansive and Hydrocompacting Soils

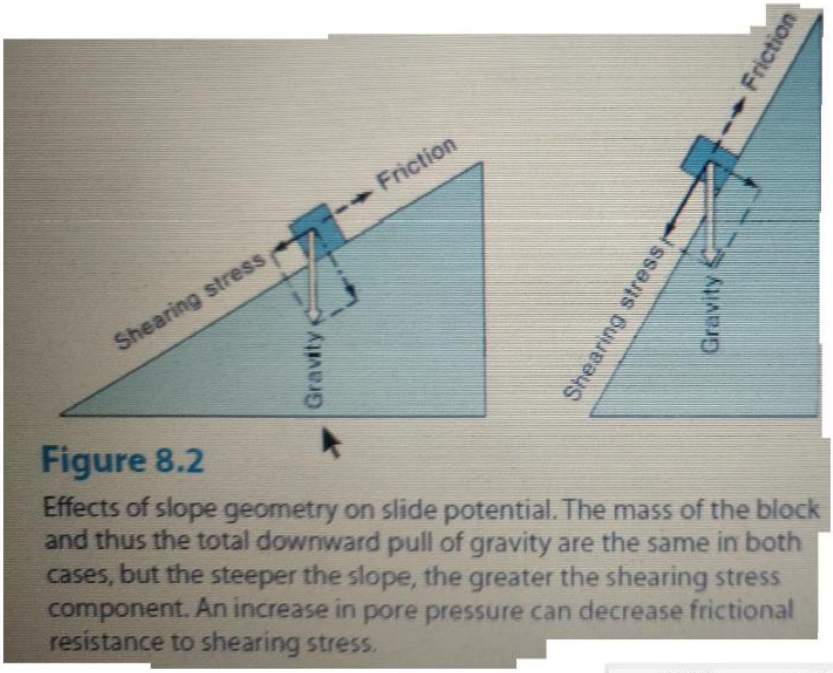
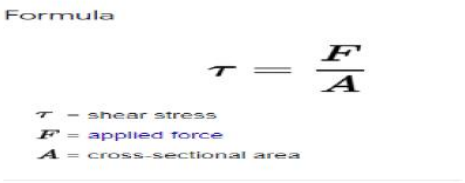


Figure 8.2

Effects of slope geometry on slide potential. The mass of the block and thus the total downward pull of gravity are the same in both cases, but the steeper the slope, the greater the shearing stress component. An increase in pore pressure can decrease frictional resistance to shearing stress.



Q. 5 (a) An undisturbed sample of silty sand was brought to the laboratory at its natural water content, and the total mass at the natural water content was 1550 g. the mass of oven-dried sample was found to be 1320 g. Total volume of sample was 730 cm^3. If the Density of the mineral solids is 2.65 g/cm^3, calculate the porosity and void ratio. [5 marks]

Ans: There are two easy methods to solve the problem

Method 1:

By using the formula for porosity determination from density

$$n = 100\left[1 - \frac{\rho_b}{\rho_d}\right]$$

Where ρ_d is grain density and ρ_b is dry bulk density

Grain density is 2.65 g/cc and dry bulk density is 1320/730 = 1.808 (**1 mark**)

Thus, porosity will be 31.77% (**2 marks**)

Void ratio is, $e = \frac{n}{1-n}$

Void ratio = 0.3177/0.6823 = 0.4656 or 46.56%(**2 marks**)

Method 2:

Grain density is 2.65 g/cc and dry mass of sample is 1320 g.

Thus, volume of solid will be 1320/2.65 = 498.11 cc

Hence, volume of voids will be 730-498.11 = 231.89 cc (**1 mark**)

[Note: volume of voids is not equal to volume of water in this case as the sample is not mentioned to be at 100% saturation. Thus, it is wrong to assume volume of water as equal to void volume]

Porosity = volume of voids/total volume

= 231.89/730 = 0.3176 or 31.76% (**2 marks**)

Void ratio = void volume/solid volume

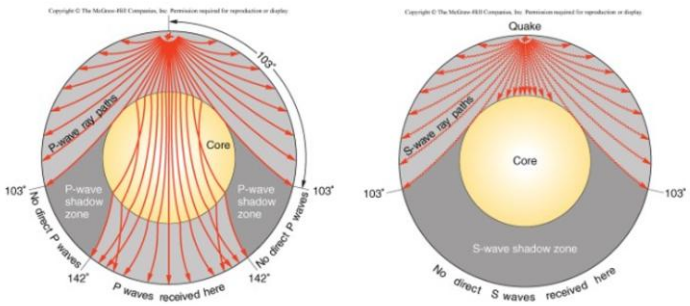
= 231.89/498.11 = 0.4655 0r 46.55% (**2 marks**)

Q5b. **Define the two seismic shadow zones of Earth's Interior (mention the range of the shadow zone in both cases) and explain in one line why these shadow zones suggest? Draw diagrams and label the shadow zones properly (3+2 marks).**

Ans. Two seismic shadow zones are 1) P-wave shadow zone ranging from 103° to 142° and 2)S-wave shadow zone ranging from ≥ 103° from epicentre in both cases.P-wave shadow zone suggest that refraction of seismic waves encountering core-mantle boundary and S-wave shadow zone suggest that Earth's outer core is liquid.

Seismic Shadow Zones

- *P-wave shadow zone* (103°-142° from epicenter) explained by refraction of waves encountering core - mantle boundary
- *S-wave shadow zone* (≥103° from epicenter) suggests outer core is a liquid



Q. No.5c) Differentiate between Surface waves and body waves with diagrams. [Max marks= 5]

Answer: Surface waves travel only through solid media. They are slower-moving than body waves but are much larger and therefore more destructive. Surface waves usually have larger amplitudes and longer wavelengths than body waves, and they travel more slowly than body waves do.

Body waves can move through all states of matter including rocks and molten lava. Surface waves can only travel on the surface of the earth. Body waves are of two types: Primary waves (also called P-waves, or pressure waves) and Secondary waves (S-waves, or shear waves).

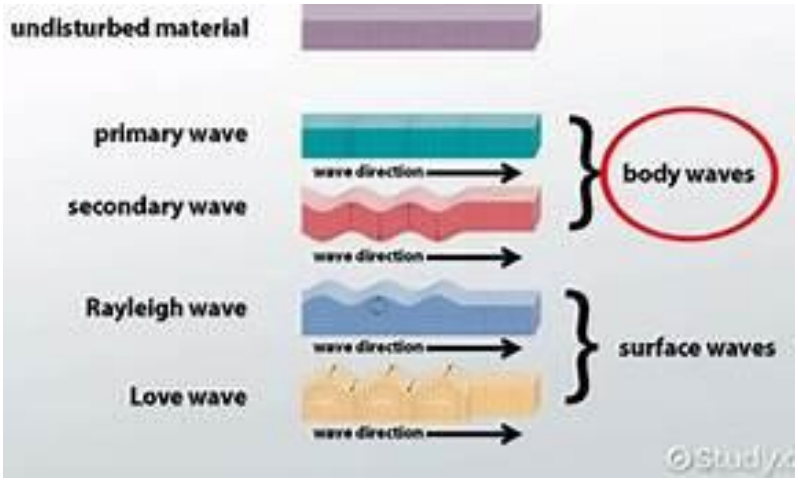
Body waves travel through the interior of the Earth. On the other hand, surface waves propagate only at the interface between two different media, like the interface between Earth and atmosphere (i.e. the surface of the Earth).

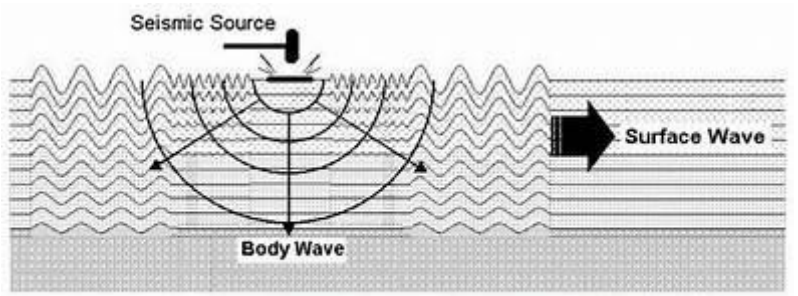
Body waves are of two types: Primary waves (also called P-waves, or pressure waves) and Secondary waves (S-waves, or shear waves).

P-waves are compression waves. They can propagate in solid or liquid material.

S-waves are shear waves. They only propagate in solid material.

By studying the trajectories of S-waves, scientists could prove that the Earth had a liquid outer core.





Two major groups of seismic waves: body and surface waves. Body waves propagate through the body, whereas surface waves travel along the surface of the medium.

Q5d. Define plutonic rocks? Write the name of two plutonic rocks with their typical characteristics? [2+3=5 marks]

Ans: Plutonic rocks are igneous rocks produced due to the slow cooling of rising magma at deeper part of the earth. Generally, they are coarse grained and occur as intrusive bodies like dykes, batholiths etc. Plutonic rocks can be felsic or mafic/ultramafic in nature
Example of two Plutonic rocks
Granite: Felsic igneous intrusive/plutonic rocks, coarse grained with dominated quatz and feldspar minerals
Gabbro: Mafic igneous intrusive/plutonic rocks, coarse grained with dominated ferromagnesian minerals (pyroxene) and feldspar minerals.

Other plutonic rocks are diorite, monzonite, dunite, peridotite, pyroxenite