UNIT I - FLUID PROPERTIES AND FLUID STATICS

Fluid – definition, distinction between solid and fluid - Units and dimensions - Properties of fluids - density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillarity and surface tension - Fluid statics: concept of fluid static pressure, absolute and gauge pressures - pressure measurements by manometers and pressure gauges- forces on planes – centre of pressure – bouncy and floatation.

Fluid Mechanics:

Fluid Mechanics is the study of fluids at rest or in motion.

Application of Fluid Mechanics:

- Design of canal,leeve,Dam Systems
- Design of Pumps, compressors
- Piping and ducting in water and a/c systems
- Piping in Chemical Plants
- Aerodynamics of automobiles, sub and supersonic airplanes
- Development of flow measurement devices
- Environmental and Energy Issues
    - Oil Slicks
    - Large scale wind turbines
    - Aerodynamics of Large Buildings
    - Energy generation from ocean waves
- Fluid Mechanics of Tornadoes,Hurricanes,Tsunamis
- Biomechanics

Fluid Definition:

- Fluid tend to flow when we react with them; Solid tend to deform or bend.
- A Fluid is a substance that deforms continuously under the application of a shear (tangential) stress no matter how small the shear stress may be.
- This continuous deformation under the application of shear stress constitutes flow.

Distinction between Solid And Fluid:

SOLID	**FLUID**
More Compact Structure	Less Compact Structure
Attractive Forces between the molecules are larger therfore more closely packed	Attractive forces between the molecules are smaller therefore loosely packed
Solids can resist tangential stress in static condition	Fluids cannot resist tangential stress in static condition
Whenever a solid is subjected to shear stress, it undergoes a definite deformation α or breaks. α is proportional to shear stress upto limiting condition.	Whenever a fluid is subjected to shear stress, there is no fixed deformation Continuous deformation takes place until the shear stress is applied.
Solid may regain partly or fully it's original shape when the tangential stress is removed.	A fluid can never regain it's original shape , once it has been distorted by the shear stress

Units and Dimensions:

- A dimension is the measure by which a physical variable is expressed quantitatively.
- A unit is a particular way of attaching a number to the quantitative dimension.
- While a dimension expresses a specific type of physical quantity, a unit assigns a number so that the dimension can be measured.
- All measurable quantities are subdivided into primary and derived quantities.
- Primary Quantities – are in sense independent of each other
- Derived / Secondary Quantities – Derived from primary quantities

In 1999, NASA's Mars Climate Observer crashed because JPL engineers assumed that measurement was in m, but the supplying company's engineers had actually made in ft!

Basic Units:

Quantity	Unit	Symbol
Length	Metre	M
Mass	Kilogram	Kg
Time	Second	s
Electric Current	Ampere	A
Thermodynamic Temperature	Kelvin	K
Luminous Intensity	Candela	cd
Plane Angle	Radian	rad
Solid Angle	Steradian	sr

Force	Newton	N

Derived Quantity :

Some Derived Quantities are,

Quantity	Unit	Symbol
Area	Metre square	m^2
Velocity	Metre per second	m/s

Properties of Fluid:

Mass Density:

- Mass Density of a fluid is the mass which it possesses per unit volume
- It is denoted by ρ
- Mass density is proportional to number of molecules in aunit volume of the fluid
- Mass Density increases with increasing temperature and pressure.

$$\rho = \textbf{mass /volume} \ (\textbf{Kg/m}^3)$$

Specific weight:

- Specific weight of a fluid is the weight it posses per unit volume.
- w(γ) = weight/volume (N/m^3)
- As it represents the force exerted by gravity on a unit volume of fluid , it has units of force per unit volume
- The mass density and specific weight is related as ,

$$\gamma = \rho g$$

- The specific weight depends on gravitational acceleration, mass density, temperature and pressure.

Specific Volume:

- Specific Volume of a fluid is the volume of the fluid per unit weight.
- V = volume/ unit weight
- Unit is m^3/N

Specific Gravity:

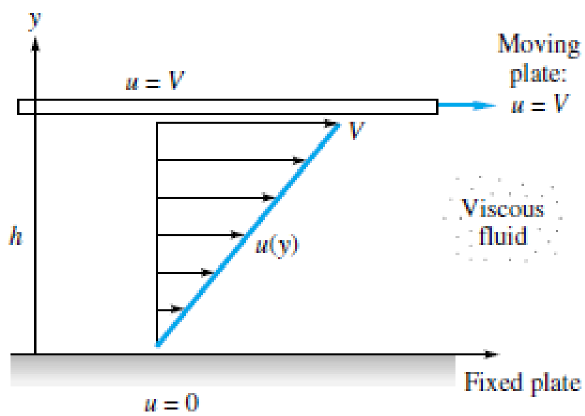
- Specific gravity is the ratio of specific weight (or mass density) of a fluid to the specific weight(or mass density) of a standard fluid.
- Standard Liquid- Pure water at 4° C (39.2 ° F)
- Standard Gas -Hydrogen/Air @ some temperature and Pressure

Temperature:

- Temperature causes water molecules to more quickly, because each individual molecule has more energy as it gets more hotter(according to kinetic molecular theory)

Viscosity:

- Viscosity is the property of a fluid by virtue of which it offers resistance to the movement of one layer of fluid over adjacent layer.
- It is primarily due to cohesion and molecular momentum exchange between fluid layers, and as flow occurs,these effects appear as shearing stresses between the moving layers of fluid.



Dynamic Viscosity:(μ)

- Newton's Law of viscosity gives the relation between shear stress and velocity gradient

$$\tau = \mu . (dv/ dy)$$

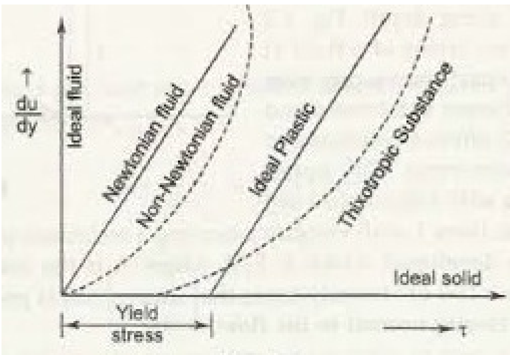
μ. represents a proportionality constant, referred as dynamic viscosity

- μ, may be defined as the shear stress required to produce unit rate of angular deformation
- In SI unit, Ns/m^2 or Kg/ms
- g/cms is named as poise
- 1/100 = centipoise

Kinematic Viscosity:

- The name kinematic viscosity has been given to the ratio(μ./ρ) because; kinematics is defined as the study of motion without regard to cause of the motion and is concerned with length and time only.(unit is m^2/s)
- cm^2/s is referred as stoke

Variation of Shear stress with velocity gradient:



Newtonian Fluid:

- In Newtonian Fluid ,there is a linear relation between the magnitude of shear stress and resulting rate of deformation
- Constant rate of proportionality,μ
- μ doesnot change with rate of deformation
- Eg: Water , Kerosene etc.,

Non-Newtonian Fluid:

- In non-newtonian fluid , there is a nonlinear relation between the magnitude of applied stress and rate of angular deformation.
- Eg: Mud flows,blood

Plastic Fluid:

- In case of a plastic substanse which is a non-newtonian fluid an initial yield stress is to be exceeded to cause continuous deformation.
- An ideal plastic has a definite yield stress and a constant relation between shear stress and rate of angular deformation.
- Eg: Sewage Sludge, Drilling Muds

Thixotrophic Substance:

- A thixotrophic substance ,which is a non-newtonian fluid has non-linear relationship between shear stress and the rate of angular deformation , beyond an initial yield stress
- Eg. Printer's Ink

Ideal Fluid:

- Ideal fluid is defined as that having zero viscosity or in other words shear is always zero regardless of the motion of the fluid
- Has zero viscosity
- Thus an ideal fluid is represented by horizontal axis(τ=0)
- True Elastic Solid may be represented by vertical axis of the diagram.

Vapour pressure:

- All Liquids possess a tendency to evaporate or vaporize
- Such vaporization occurs because of continuous escaping of molecules through free liquid surface
- When the liquid is confined in aclosed vessel ,the ejected vapour molecules get accuumulated int he space between the free liquid space an top of the vessel.
- This accumulated vapour of the liquid exerts a partial pressure on the liquid surface which is known as vapour pressure of the liquid
- As as result pockets of dissolved gases and vapours are formed.
- The bubbles collapse at region of high pressure, giving raise to high impact pressure causing cavitation.

Compressibility and Elasticity:

- All Fluids may be compressed by the application of external force, and when the external force is removed,the compressed volumes of fluid expand to their original volume.
- Compressibility of a fluid is quantitatively expressed as inverse of bulk modulus, i.e. 1/K
- The bulk modulus of elasticity is a measure of incremental change in pressure (dp) which takes place when a volume V of the fluid is changed by an incremental amount dV.

$$K= -dp/(dV/V)$$

- Since a rise in pressure always cuses a decrease in volume; dV is always negative ; and thus negative sign is included in the equation to give positive value of K.

Surface Tension:

- Due to molecular attraction, liquid possess certain properties such as cohesion and adhesion.
- Surface tension is due to cohesion
- Capillarity is due to cohesion and adhesion.
- The property of the liquid surface film to exert tension is called the surface tension, denoted by **σ**
- S.I unit is N/m
- It is also dependent on the fluid in contact with the liquid surface.
- Pressure intensity inside a droplet,

$$P= 2 \sigma / r$$

- Pressure intensity inside a soap bubble,

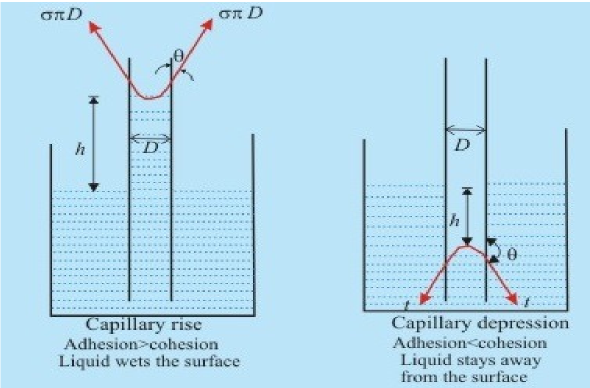
$$P= 4 \sigma / r$$

- Pressure intensity inside a Liquid Jet,

$$P= \sigma / r$$

Capillarity:

- The phenomenon of rise or fall of liquid surface relative to the adjacent general level of liquid is known as capillarity.
- S.I unit – m/mm of liquids



- The Capillary rise is given by,

  $h=(2\ \boldsymbol{\sigma \cos \theta})/\ \boldsymbol{\gamma\ r}$
- If clean water is used, $\boldsymbol{\theta = 0}$.

Fluid Statics:

- **Fluid Statics** deals with properties of fluid at rest.
- **Fluid Element** can be defined as asn infinitesimal region of the fluid continuum in isolation from its surroundings.
- Two Types of force exist on fluid elements
  - Body Force
  - Surface Force
    - Normal Force
    - Shear force
- **Body force** is distributed over the entire mass or volume of the element.
- Eg: Gravitational Force, Emf Force fields.
- **Surface force**-Forces exerted on the fluid element by its surroundings through direct contact at surface
- Shear Force is zero for any fluid element at rest
- **Pressure or intensity of Pressure** may be defined as the force exerted on unit area.
- In SI units- N/m^2

Variation of Pressure in a Fluid @ rest:

The expressions derived from the derivations are:

- $\partial p/\partial x = 0$
- $\partial p/\partial y = 0$
- $\partial p/\partial z = -\rho g$

Assumptions made are

- It is applicable for both compressible and non-compressible fluid
- Negative sign indicates 'P' increases in downward direction
- If dz=0 ; i.e. @ horizontal Plane , Pressure is constant.

In Liquids, at the free surface, atmospheric Pressure (**Pa)**exists. If a Point lies at height 'h' from free surface,the pressure acting at that point is given by,

$P = \boldsymbol{\gamma h + Pa}$

Inference from the above equation are,

- Pressure @ any point in static mass of fluid depends only on vertical depth from free surface and specific weight
- It doesnot depend on shape or size of container.
- Often Pressure in excess of atmospheric pressure is considered.

Pressure Head:

- The vertical height of the free surface above any point in a liquid at rest is known as pressure head.

  $h = P/\gamma$

Pascal's Law:

- When a certain pressure is applied at any point in a fluid at rest, the pressure is equally transmitted in all directions and to every other point in the fluid.

  $Px = Py = Pz$

Applications of Pascal Law:

- Hydraulic Press
- Hydraulic Jack
- Hydraulic Lift
- Hydraulic Crane
- Hydraulic meter

Atmospheric , Absolute Gauge and Vacuum Pressure:

Atmospheric Pressure:

- The atmospheric air exerts a normal pressure upon all surfaces with which it is in contact ,and it is known as atmospheric pressure.
- The atmospheric pressure varies with the altitude.
- Measured by means of barometer and it is known as barometric Pressure.

Fluid Pressure may be measured with respect to any arbitrary datum.

The two most common datums used are,

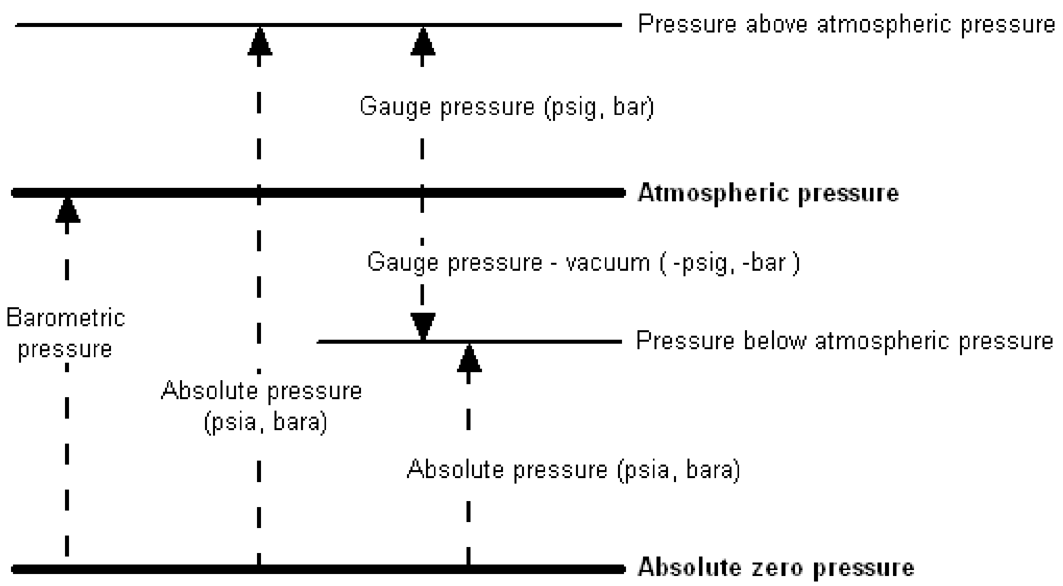
- Absolute zero pressure
- Local Atmospheric Pressure

Asolute Pressure:

When the pressure is measured above absolute zero (or complete vacuum), it is called absolute Pressure.

Gauge Pressure:

- When Pressure is measured either above or below atmospheric pressure as datum it is called gage pressure.
- All Gages read zero when open to atmosphere
- If Pressure below Atmospheric pressure , it is called vacuum Pressure/ suction pressure/Negative gage Pressure



Absolute Pressure =Atmospheric Presure + Gage Pressure
Absolute Pressure =Atmospheric Presure – vacuum Pressure

Pressure Measurements:

Manometers:

- Manometers are those pressure measuring devices which are based on the principle of balancing the column of liquid (Whose pressure is to be found) by the same or another column of liquid.
- The Manometers may be classified as,
    - Simple Manometer
    - Differential Manometer

Simple Manometer:

- Simple manometers are those which measure pressure at a point in a fluid contained in a pipe or a vessel.

Differential Manometer:

- It helps to measure the difference of pressure between any two points in a fluid contained in a pipe or vessel.

Simple Manometer:

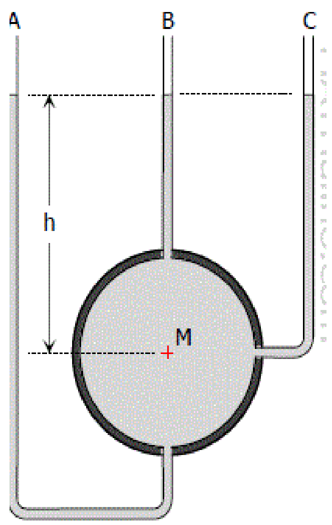
- In general a simple manometer consist of a glass tube having one end(gage Point) at which pressure p is to be measured,another end is open to atmosphere.

Some of the common types of simple manometer are

- Piezometer
- U-Tube Manometer
- Single Column Manometer

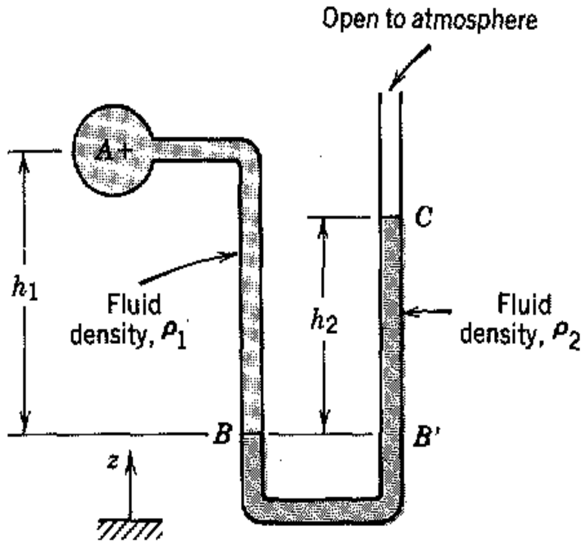
Piezometer:

- Simplest Form of manometer
- Measures moderate pressure
- Gives gauge pressure because it is open to atmosphere
- Piezometer consist of a glass tube inserted in the wall of a pipe / vessel, containing liquid whose P is to be found
- The glass tube may be inserted either in top, bottom or side of the container.
- It is used to measure pressure head at moving fluids too.
- It cannot measure larger pressure*(it would need long tubes)
- Gas Pressure cannot be measured *('cause gas have no open free atmospheric surface)



U-tube Manometer:

- Piezometer's Limitation is overcome by U-Tube Manometer.
- It consists of U tube (glass tube bent in u shape) , one end of which is connected to gauge point and another end to atmosphere.
- Tube contains a liquid having specific gravity than the liquid whose pressure is to be measured



Manometric Fluid:

- Manometric Fluid should not mix with liquids whose pressure is to be measured .
- Fluids used are mercury,oil, salt solution, Carbon disulphide,Carbon tetrachloride,Bromoform,alcohol etc.,
- Choice of fluid depend on range of pressure to be measured
  - Low range- Low specific gravity liquid
  - High Range -Mercury
- Manometric Fluid should not wet the wall, should not absorb gas, should have low vapour pressure

Procedure to find pressure:

Any units of pressure may be used.But it is generally convinient to express all terms in metres of fluid whose pressure is to be measured. The following general procedure may be adopted to obtain gage equation:

1. Start from A/ open end of the manometer
   - A --> If pressure is unknown express in appropriate unit
   - Open end --> Atmospheric Pressure, ; P=0 ('Cause we consider only gauge pressure)
2. To the pressure found above , add the change in pressure(in same units) while proceeding from one level to another adjacent level of contact of liquids of different specific gravities.

Positive sign	If next is lower than first
Negative Sign	If next is higher than first

Note: Pressure head in terms of the heights of columns of same liquid may be obtained by, $P=S_1 h_1 = S_2 h_2$

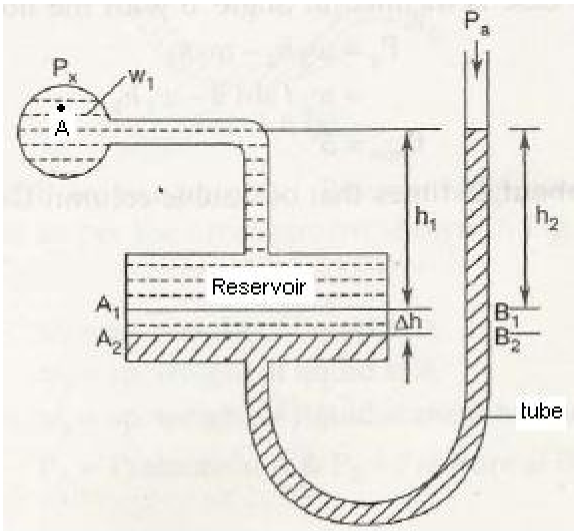
3. Continue the process as in (2) until the other end of the gauge is reached and equate the expression to the pressure at that point, known or unknown. The expression will contain only one unknown viz., the pressure at A , which may thus be evaluated.

Limitations of U-tube Manometer:

- Pressure Change cause rise in one limb and drop in another, so we have to read readings at two or more points
- This difficulty is overcome by single column Manometer.

Single column Manometer:

- Modified form of U-tube manometer
- A shallow reservoir having large c/s area(100 times the area of the tube) is introduced in one limb
- Shallow reservoir need not be made of transparent material
- For Pressure change, change in liquid level in reservoir may be neglected; i.e., no reading is taken in shallow reservoir
- The pressure change is indicated in the other limb by the height of the liquid.
- The narrow limb may be vertical/inclined.



Pressure at A is given by,

$$P_A/\gamma = h_2(S_2 + (S_2-S_1)a/A)$$

- Single Column manometer is made more sensitive by making its narrow tube inclined.
- Even for small pressure change , differenced in liquid level is comparitively more.
- Pressure at A is given by,

$$P_A/\gamma = h_2(S_2 \sin\theta + (S_2-S_1)a/A)$$

Differential Manometer:

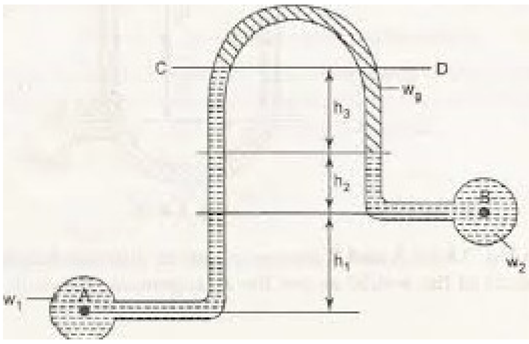
- It is used for measuring difference in pressure in two pipelines/containers.
- Some of the common type of Differential manometer are
  - Two-Piezometer manometer
  - Inverted U-tube Manometer
  - U-tube differential Manometer
  - Micromanometer

Two-piezometer Manometer:

- It is used to measure small pressure
- Two Piezometers connected at two point
- Difference in their liquid levels give 'Δp' @ that two points
- Cannot measure 'Δp' in gases using this type of manometer

Inverted U-Tube Manometer:

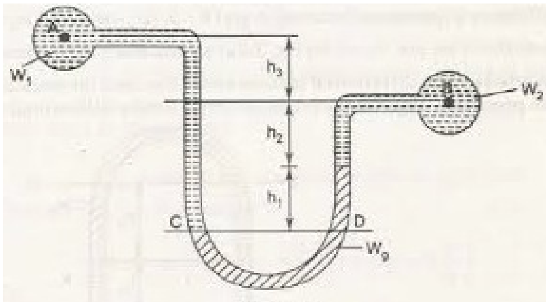
- It consists of an inverted U-Tube
- Pressure causes air to compress air @ one limb and expand @ other end.



- Aircock is inserted at the top of the tube for releasing compressed air for measurement and release air bubbles
- 'Δp' causes release of air bubbles.

U- tube Differntial Manometer:

- A U-tube Manometer which is used to measure difference in pressure in two points.



- If at same level, the pressure difference is given by,

$$P_A/\gamma - P_B/\gamma = x(S_2 - S_1)$$

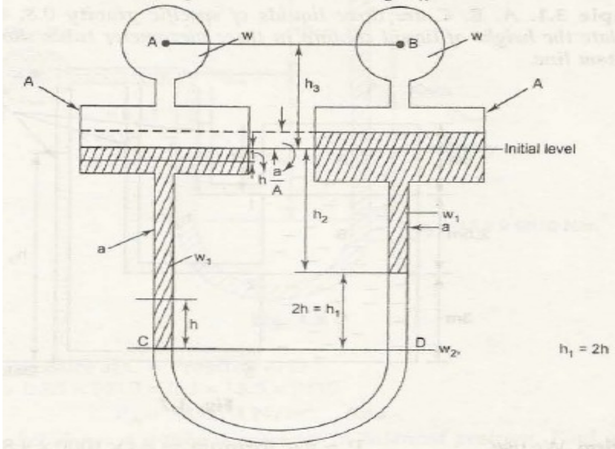
- If at different levels, the pressure difference is given by,

$$P_A/\gamma - P_B/\gamma = x(S_2 - S_1) - z\,S_1$$

Where , x is the difference in the manometric fluid level
z is the difference in the levels of the tube

Micromanometer:

- It is used to even measure even small pressure differences accurately, or measure 'Δp' with high precision, i.e., they magnify readings or permit the readings to be observed with greater accuracy.



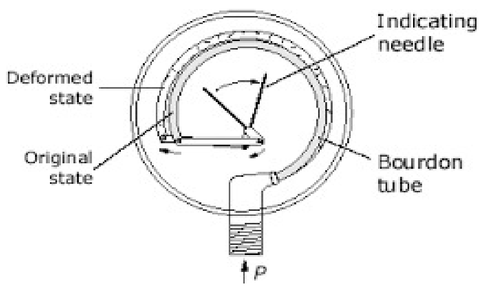
- It consist of U-tube (area -a);connected to two transparent wider sections(area- A).
- Consists Of two manometric Fluid; Immiscible with each other.
- If a/A is negligible, the pressure difference is given by,

$$P_A/\gamma - P_B/\gamma = x(S_2 - S_1)$$

- Specific Gravities of the two manometric fluid are very nearly equal.
- Micrometer screw is used to adjust the pressure differences.
- These devices are sensitive to pressure differences down to less than 0.0025 mm of water.
- The disadvantages are
  - Appreciable time is required to take a reading
  - suitable only for completely steady pressures

Mechanical Gauges:

- Pressure Measuring devices
- It embodies an elastic element ,which deflects undere the action of the applied pressure, and this movement mechanically magnified, operates a pointer moving against a graduated circumferential scale.
- Used to measure high pressures , where high precision is not required.
- Some of the common gauges are
  - Bourdon Tube Pressure gage
  - Diaphragm Pressure gage
  - Bellows Pressure gage
  - Dead weight Pressure gage



Bourdon Pressure Gage

Total Pressure:

- When a static mass of fluid comes in contact with a surface, either plane or curved, a force is exerted by the fluid on the surface. This force is known as Total Presure
- For a fluid at rest,
  - No tangential force exists
  - Total Pressure acts in the direction normal to the surface
- Centre of Pressure:
  - The point of application of total pressure on the surface is known as centre of pressure

Condition of Plane	Total Pressure	Centre Of Pressure
Horizontal plane	$P= \gamma hA$	Acts at centroid
Vertical Plane	$P = \gamma \bar{x} A$	Centre of pressure lies below centre of gravity
Inclined Plane	$P = \gamma \bar{x} A$	Centre of pressure lies below centre of gravity

Pressure Diagram:

- A pressure diagram is a graphical representation of the variation of the pressure intensity over a surface.
- It may be scaled

Practical applications of Total Pressure and centre of Pressure:

- In practice , hydraulic structures are subjected to hydrostatic forces, therefore it is necessary to compute magnitude of these forces and to locate their points of application on these structures.
- Some of the common type of structures
  - Dams
  - Gates
  - Tanks

Buoyancy:

- When a body is immersed in a fluideither partially or wholly ,it is subjected to an upward force which tends to lift it up.
- This tendency for an immersed body to be lifted up in the fluid, dur to an upward force opposite to the action of gravity, is known as buoyancy.
- The force tending to lift up the wholly or partially immersed body is known as Buoyant force.
- The point of application of force of buoyancy on the body is known as centre of buoyancy.
- The magnitude of the buoyant force can be determined by Archimedes principle which states that," When a body is immersed in afluid either wholly or partially, it is buoyed or lifted up by a force which is equal to the weight of the fluid displaced by the body."
- Buoyant force is given by,

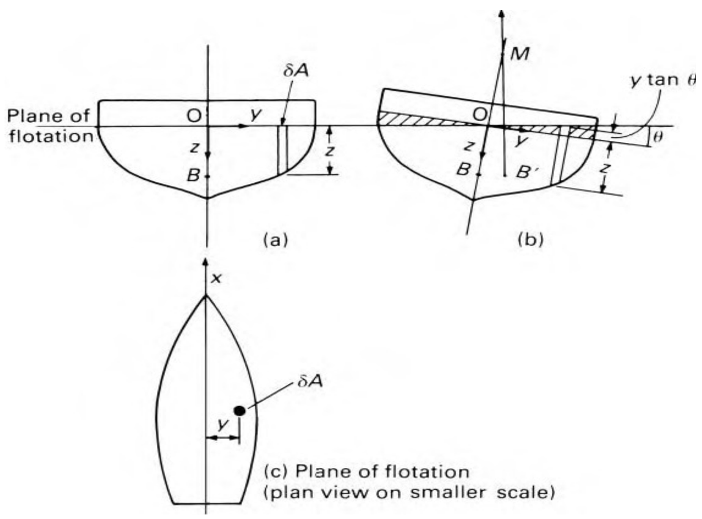
$$F_B = \gamma V$$

Where,

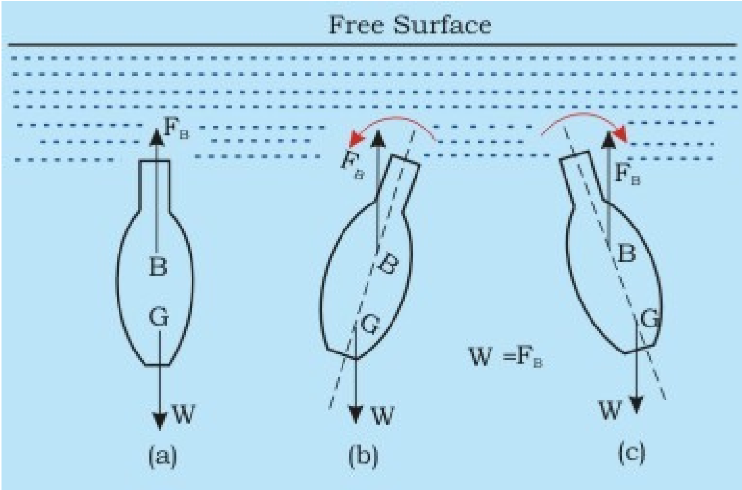
- V is the volume of submerged body
- γ is the unit weight of fluid
- F_B is the buoyant force

The stability of floating bodies:

The condition for angular stability of a body floating in a liquid is a little more complicated. This is because, when the body undergoes an angular displacement about a horizontal axis, the shape of the immersed volume in general changes, so the centre of buoyancy moves relative to the body. As a result stable equilibrium can be achieved even when G is above B.



- In a new position of a floating body, centre of gravity doesnot change, whereas centre of buoyancy. Because when it is tilted, portion of body immersed in right hand side increases and left hand side decreases.
- The point of intersection of vertical axisand extended line of action of buoyant force is called metacentre
- The distance between centre of gravity and metacentre is called matacentric height.



Stable	If centre of gravity is below centre of buoyancy	It comes back to original position
Unstable	If centre of buoyancy is below centre of gravity	Increases the displacement further
Neutral	If both centre of gravity and centre of buoyancy coincides	It adopts a new Position

- For a floating body, stability is based on centre of buoyancy and centre of gravity and metacentre.

UNIT II FLIUD KINEMATIC S AND DYNAMICS

Fluid Kinematics - Flow visualization - lines of flow - types of flow - velocity field and acceleration - continuity equation (one and three dimensional differential forms)- Equation of streamline - stream function - velocity potential function - circulation - flow net. Fluid dynamics - equations of motion - Euler's equation along a streamline - Bernoulli's equation – applications - Venturi meter, Orifice meter and Pitot tube. Linear momentum equation and its application.

Fluid Kinematics:

- The science which deals with the geometry of motions of fluids without references to the forces causing the motion is known as hydrokinematics or simply kinematics.

Flow Visualization:

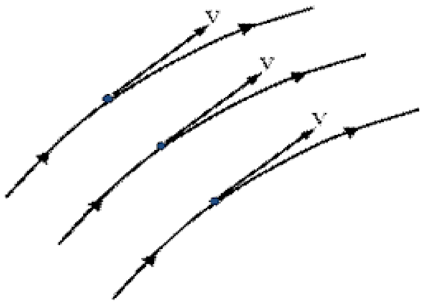
- Flow visualization is used to make the flow patterns visible, in order to get qualitative or quantitative information on them
- For eg., Particle image velocimetry (PIV) is an optical method of flow visualization used in eduation and research

Lines of Flow:

- Stream Line
- Path Line
- Streak Line

Stream Line:

- A stream line is an imaginary curve drawn through a flowing fluid in such a way that the tangent to it at any point gives the direction of the velocity of flow at that point.



$v/u = \tan\theta = dy/dx$

The general differential equation for streamline,

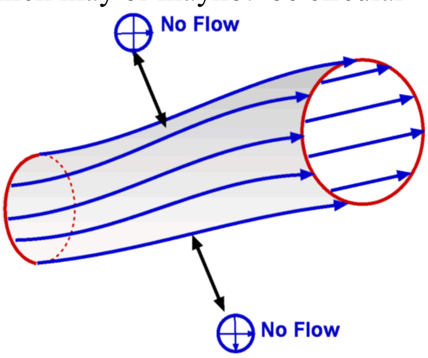
For 2D;

$dy/v = dx/u$

For 3 D;

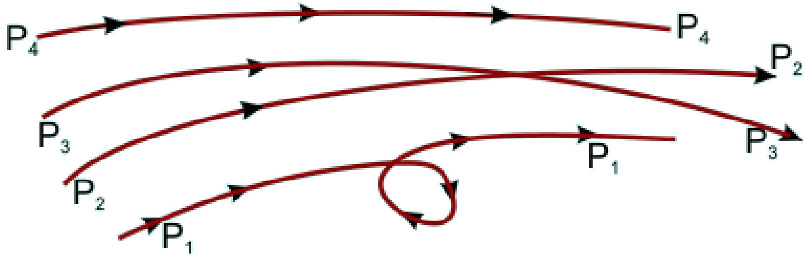
$dy/v = dx/u = dz/w$

- **A stream tube** is a tube imagined to be formed by a group of streamlines passing through a small closed curve, which may or maynot be circular



Pathline:

- A path line may be defined as the line traced by a single fluid particle as it moves over a period of time.



Streak line:

- Streak line may be defined as a line that is traced by a fluid particle passing through a fixed point in a flow field.
- In steady state, stream line = Path line = streak line
- In unsteady flow, a streak line at any instant is the locus of end points of particle paths that started @ the instant the particle passed through injection point.

Methods of description:

- Langrangian Method – Individual particle selected, which is pursued throughout the course of motion and observations is made about the behaviour of particle through space.
- Eulerian Method: - In Eulerian method, any point in the space occupied by the fluid is selected and observation is made of whatever changes of V, P, ρ which takes place at that point.
    - This method is commonly used in fluid mechanics.

Velocity field:

- A fluid unlike solid is composed of different particles, which move @ different velocity and may be subjected to different accelerations
- Moreover, V and a change both with respect to time and space
- The motion of a fluid like that of solid is described quantitatively in terms of the characteristic known as velocity.
- **Velocity** at any point of fluid mass is expressed as the ratio between displacement of fluid element along its path and corresponding increment of time as the later approaches to zero.

$$V = \lim_{dt \to 0} ds/dt$$

- The velocity is a vector quantity and hence it has magnitude as well as direction.
- V is resolved into u,v,w in x,y,z direction.

$$u = \lim_{dt \to 0} dx/dt$$
$$v = \lim_{dt \to 0} dy/dt$$
$$w = \lim_{dt \to 0} dz/dt$$

Acceleration:

- Acceleration is defined as the rate of change of velocity with respect to time
- The acceration in x,y,z directions is given by,

$$a_x = \lim_{dt \to 0} du/dt$$
$$a_y = \lim_{dt \to 0} dv/dt$$
$$a_z = \lim_{dt \to 0} dw/dt$$

- The substantial derivative of u is given by,

$$a_x = u.\partial u/\partial x + v.\partial u/\partial y + w.\partial u/\partial z + \partial u/\partial t$$

- The substantial derivative of v is given by,

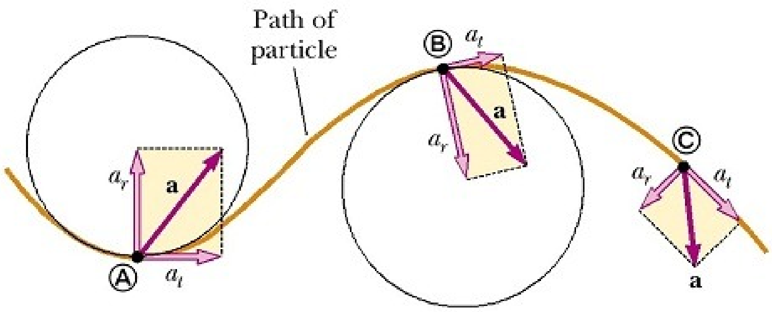
$$a_y = u.\partial v/\partial x + v.\partial v/\partial y + w.\partial v/\partial z + \partial v/\partial t$$

- The substantial derivative of w is given by,

$$a_z = u.\partial w/\partial x + v.\partial w/\partial y + w.\partial w/\partial z + \partial w/\partial t$$

- In these expressions , $\partial u/\partial t$, $\partial v/\partial t$, $\partial w/\partial t$ represents the rate of increase of velocity with respect to time at a paricular point in flow and hence it is known as local acceleration or temporal acceleration.
- The remaining terms in these expressions represent the rate of increase of velocity due to the particle's change of position and hence it is known as convective acceleration.

Tangential and Normal Acceleration:



- The tangential component of the acceleration is due to the change in the magnitude of velocity along the stream lineand the normal component of the acceleration is due to change in the direction of velocity vector.

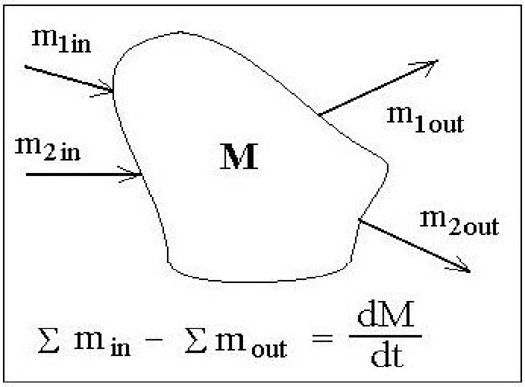
Types of flow:

Types of Flow	Codition	Expression	
Steady Flow	Fluid Properties doesnot change with time	$\partial v/\partial t = 0$	
Unsteady Flow	Fluid Properties change with time	$\partial v/\partial t \neq 0$	
Uniform Flow	Fluid Properties doesnot change with space	$\partial v/\partial s = 0$	
Non-Uniform Flow	Fluid Properties change with space	$\partial v/\partial s \neq 0$	
1D Flow	Fluid Properties are function of any one of the coordinate directions	steady	Unsteady
		V=f(x)	V=f(x,t)
2D Flow	Fluid Properties are function of any two of the coordinate directions	V=f(x,y)	V=f(x,y,t)
3D Flow	Fluid Properties are function of all three of the coordinate directions	V=f(x,y,z)	V=f(x,y,z,t)
Rotational Flow	Fluid particles while moving in the direction of flow rotate about their mass centres	Curl $V \neq 0$	
Irrotational Flow	Fluid particles while moving in the direction of flow doesnot rotate about their mass centres	Curl $V = 0$	
Laminar flow	Fluid Particles move in layer	$Re < 2000$	
Turbulent flow	Fluid Particles move in disorderly manner	$Re > 2000$	

- If there is constant diameter and constant discharge , it is steady- uniform flow
- If there is varying diameter and constant discharge , it is steady- non-uniform flow
- If there is constant diameter and varying discharge , it is unsteady- uniform flow
- If there is varying diameter and varying discharge , it is unsteady- non-uniform flow

Continuity Equation:

- Continuity Equation is actually mathematical statement of the principle of conservation of mass
- Consider a fixed region within a flowing fluid,



- Since fluid is neither created nor destroyed within the region it may be stated that ' the rate of increase of the fluid mass contained within this region must be equal to the difference between the rate at which the fluid mass enters the region and the rate at which the fluid mass leaves the region'
- The General form of continuity equation is ,

$$\partial\rho/\partial t + \partial(\rho u)/\partial x + \partial(\rho v)/\partial y + \partial(\rho w)/\partial z = 0$$

- If steady flow, $\partial\rho/\partial t = 0$, therefore the equation becomes,

$$\partial(\rho u)/\partial x + \partial(\rho v)/\partial y + \partial(\rho w)/\partial z = 0$$

- If incompressible flow, ρ doesnot change,

$$\partial(u)/\partial x + \partial(v)/\partial y + \partial(w)/\partial z = 0$$

- The simplest form of continuity equation,

$$\rho\, AV = \text{constant}$$

Velocity Potential Function:

- The velocity potential Φ(greek phi) is defined as a scalar function of space and time, such that it's negative derivative with respect to any direction gives the fluid velocity in that direction.
- Thus mathematically the velocity potential is defined as,

$$\Phi = f(x,y,z,t)$$

$u = -\partial\Phi/\partial x$	$v = -\partial\Phi/\partial y$	$w = -\partial\Phi/\partial z$

- Substituting the value of u,v,w in the continuity eq. in terms of Φ, we get,

$$\partial^2\Phi/\partial x^2 + \partial^2\Phi/\partial y^2 + \partial^2\Phi/\partial z^2 = 0$$

The above equation is called Laplace Equation.

- If velocity potential function satisfies, laplace equation, it is a irrotational flow.

Stream function ψ (greek psi):

- The stream function ψ is defined as a scalar function of space and time, such that its partial derivative with respect to any direction gives the velocity component at right angles(in counter clockwise direction) to this direction.

$$\Psi = f(x,y,t)$$

$$\partial\Psi/\partial x = v$$

$$\partial\Psi/\partial y = -u$$

$\partial\Phi/\partial x = \partial\Psi/\partial y$	$-\partial\Phi/\partial y = \partial\Psi/\partial x$

- The above equation is called cauchy-Rieman Equation.
- They enable the computation of stream function if velocity potential is known and Viceversa.
- If stream function is substituted in rotation component in z- direction , it is called Poisson Equation

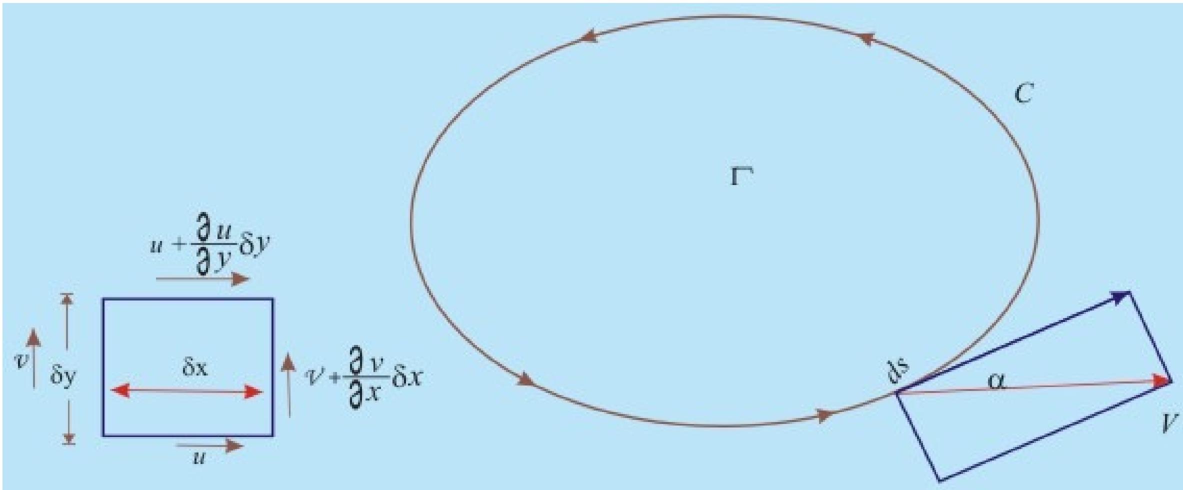
$$\omega_z = 1/2\ (\partial^2\Psi/\partial x^2 + \partial^2\Psi/\partial y^2)$$

This equation is called Laplace equation for Ψ

Circulation:

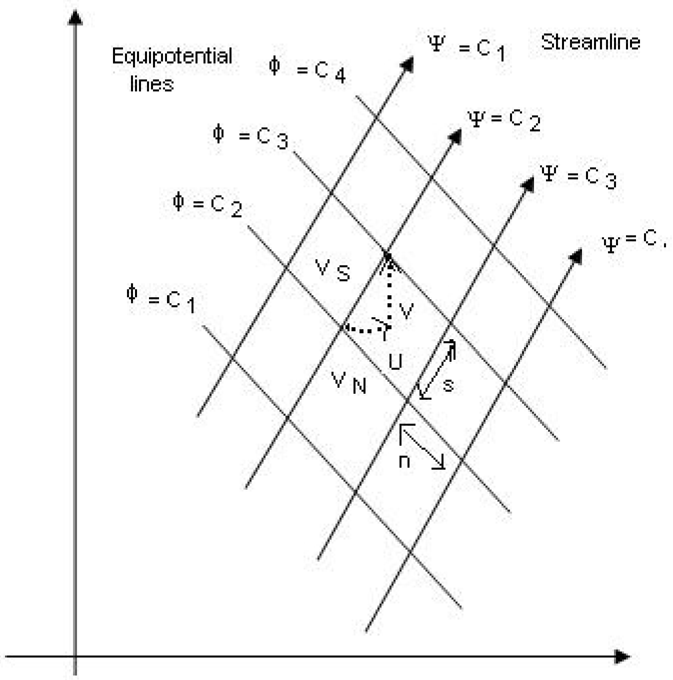
- The flow along a closed curve is called circulation(i.e., the flow in eddies and vortices)
- The mathematical concept of circulation is the line integral taken completely around a closed curve, of the tangential component of velocity vector.

Circulation, $\Gamma = {}_c\int v \cos \alpha . ds$



Flow Net:

- Stream line – Imaginary line showing flow pattern(Ψ =constant)
- Equipotential line – Imaginary curve for which velocity potential is same @every point
- A grid obtained by drawing a series of streamlines and equipotential lines is known as flownet.
- Streamlines and Equipotential Lines intersect each other orthogonally at all points of intersection.
- Flow pattern can be predicted in fluid flow with identical geometry
- velocity can be determined at points



Fluid dynamics:

- The study of fluid motion involving the consideration of the forces and energies causing the flow of fluid is known as Dynamics of fluid flow
- Forces acting on a fluid mass may be classified as
    - Body/Volume Force(eg., weight, centrifugal force)
    - Surface force(eg., shear force, pressure force)
    - Line Force(eg., surface tension)
- Dynamics of fluids are governed by Newton's second law of motion.
- i.e., sum of forces = mass X acceleration

Forces acting on Fluid in motion:

- Gravity force, Fg – The gravity force is due to the weight of the fluid and it is equal to 'mg'
- Pressure Force ,Fp - The pressure force is exerted on the fluid mass if there exsists a pressure gradient between two points in the direction of flow.
- Viscous Force ,Fv - The viscous force due to the viscosity of the flowing fluid
- Turbulent force ,Ft – The force is due to turbulence of the flow.
- Surface Tension force Fs – This force is due to the cohesive property of the fluid mass
- Compressibility force Fe – This force is due to the elastic property of the fluid.

Equation of motion :

- $Ma = Fg + Fp + Fv + Ft + Fs + Fe$

Reynold's Equation of motion :

- $Ma = Fg + Fp + Fv + Ft$

Navier's stokes equation:

- $Ma = Fg + Fp + Fv$

Euler's Equation of Motion:

- $Ma = Fg + Fp$

Euler's Equation of motion:

The equation of motion in which the forces due to gravity and pressure are taken into account. This is derived by considering the motion of a fluid element along a streamline as;

$$dp/\rho + g\,dz + v\,dv = 0$$

Bernoulli's Equation from Euler's Equation

Bernoulli's eqaution is obtained by integrating the Euler's equation of motion as,

$$P/\rho g + v^2/2g + z = \text{constant}$$

Where,

$(P/\rho g)$ is Pressure Head

$(v^2/2g)$ is velocity Head

z is the Datum Head

The Assumptions are,

- The fluid is ideal i.e., viscosity is zero
- The flow is steady
- The flow is incompressible
- The flow is irrotational

Bernoulli's Equation For Real Fluid:

The Bernoulli'sequation was derived on the assumption that the fluid is inviscid (non-viscous) and therefore frictionless. But all real fluids are viscous and hence offer resistance to flow. Thus there are always some losses in fluid flows and hence in application of Bernoulli's equation, these losses have to be taken into consideration. Thus the Bernoulli's equation for real fluids between points 1 and 2 is given as,

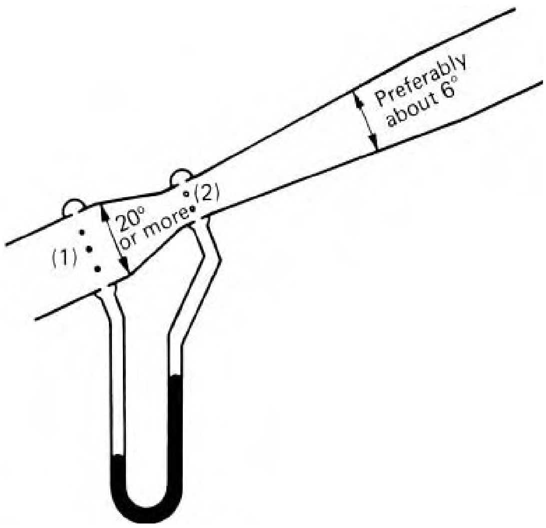
$$P_1/\rho g + v_1^2/2g + z_1 = P_2/\rho g + v_2^2/2g + z_2 + h_l$$

Applications of Bernoulli's Equation:

- Venturimeter
- Orificemeter
- Pitot Tube

Venturimeter:

- The device consists essentially of a convergence in a pipe-line, followed by a short parallel-sided throat and then a divergence known as a diffuser. Continuity requires a greater velocity at the throat than at the inlet;there is consequently a difference of pressure between inlet and throat, and measurement of this pressure difference enables the rate of flow through the meter to be calculated.
- Actual Discharge is given by,

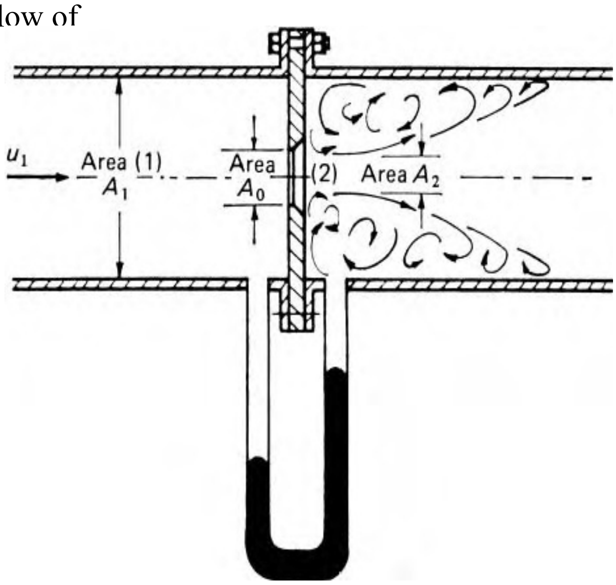


$$\mathbf{Q_{act} = \frac{C_d\, a_2\, a_1 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}}$$

$$\mathbf{h = x((S_h - S_o) - 1)}$$

Orificemeter:

- Device used for measuring the rate of flow of a fluid through a pipe
- It consists of a flat circular plate which has a circular sharp edged hole called orifice
- Orifice diameter = 0.5 (pipe diameter)
- Vena contracta is a point in a fluid stream where diameter of the stream is the least and fluid velocity is @ its maximum.
- The actual discharge is given by,



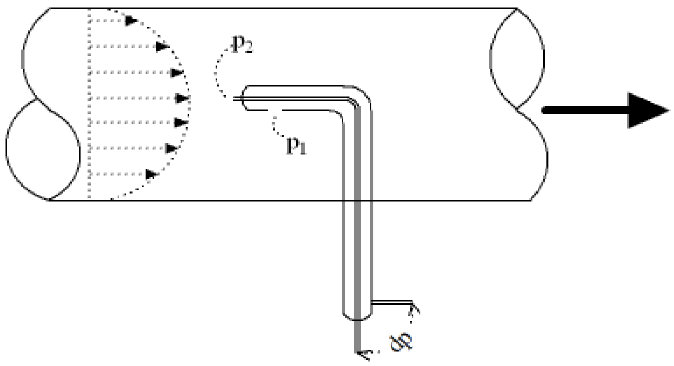
$$Q_{act} = \frac{C_d\, a_2\, a_1 \sqrt{(2gh)}}{\sqrt{(a_1^2 - a_2^2)}}$$

- The cofficient of discharge for orificemeter is much smaller than that for a venturimeter.

Pitot tube:

- It is a device used for measuring the velocity of flow at any point in a pipe or a channel
- pitot tube consists of a glass tube bent at right angles
- The theoretical velocity is given by,

$$V = C_v \sqrt{(2gh)}$$



Linear Momentum Eqaution:

- It is based on Conservation of momentum
- It states that, ' the net force acting on a fluid mass is equal to change in momentum of flow per unit time in that direction.
- The force acting on a fluid mass is given by, Newton's second law of motion

F= ma

F = m (dv/dt)

F= d(mv)/dt, if mass is constant in a system.

The above equation is known as momentum principle.

F .dt = d(mv)

This equation is known as impulse momentum equation.

- It states that ' the impulse of a force F acting on a fluid of mass m in a short interval of time 'dt' is equal to change of momentum d(mv) in the direction of force.

Application of momentum Equation:

1. Force due to the flow of fluid round a pipe bend.
2. Force on a nozzle at the outlet of a pipe.
3. Impact of a jet on a plane surface.
4. Force due to flow round a curved vane.

DEPARTMENT: CIVIL ENGINEERING
SEMESTER: III
SUBJECT CODE / Name: AG 2211 / Applied geology

UNIT 3 TWO MARKS QUESTIONS AND ANSWERS

1.Distinguish Between Granite and Marble Rock (AUC APRIL/MAY 2010)

Rock It may be defined as plutonic light colored igneous rocks. These are among the most common igneous rocks. The work granite is derived form Latin word geranium meaning a grain and obviously refers is the equigranular texture of the

Marble is a Essentially a granular metamorphic rock composed Chiefly of recrystallized calcite. It is a Characterized by a Granular Structure but the Grain Size shows

2. List the Various types of Sedimentary and Metamorphic group
(AUC APRIL/MAY 2010)

Sedimentary group

1. Sandstone
2. limestone
3. Shale Congo
4. Ganglomerate
5. Breccias

Metamorphic group

1. Quartzite
2. Marble
3. Slate
4. Phyllite
5. Gneiss
6. Schist

3. Write about the mineral composition, origin and properties and uses of Basalt
(AUC NOV/DEC 2009)

Basalts

Definition:

Basalts are volcanic igneous rocks formed by rapid coding from lava flows from volcanoes either over the surface (or) under water on oceanic floors.

Composition:

Basalts are commonly made up of calcic plagioclase feldspars and a number of Ferro – magnesium minerals like Augite, hornblende. In fact many types of basalts are distinguished on the basis of the type and proportion of Ferro magnesia minerals in them.

Occurrence:

The basaltic rocks form extensive lava flows on the continents and also on the oceanic floors in almost all the regions of the world.

4. Bring a Short note on Dolerite (AUC NOV/DEC 2009)
Diorite:

Definition;

It is an intermediate type of igneous rock of plutonic origin with silica percentage generally lying between 52 – 66 %.

Composition:

There are typically rich in feldspar plagiocose of zodiac group, diorites also contain accessory minerals like hornblende, biotite and some pyroxenes.

Texture:

In texture, diorites show close resemblance to granites and other plutonic rocks. They are coarse to medium grained and holo-crystalline.

Occurrence:

Diorite commonly occurs as small intrusive bodies like dikes, sills, stocks and other irregular masses.

5. Give a brief Description of Limestone (AUC NOV/DEC 2011)

Lime stones

Definition:

These are the most common sedimentary rocks from the non clastic group and are composed chiefly of carbonate of calcium with subordinate proportions of carbonate of magnesium.

Composition:

limestone is invariably made up of mineral calcite ($CaCO_3$). In the limestone rock formations, however, presence of dolomite CaMg $(CO_3)_2$, quartz, (SiO_2) feldspar minerals and Iron Oxide is rather a common feature.

Texture:

The most important textural feature of limestone's in their fossiliterous nature. Other varieties of limestone's show dense and compact texture. Some may be loosely packed and highly porous. Others may be compact and homogenous.

Types:

Following are common types of limestone's:

1. Chalk:

It is the purest form of limestone characterized by fine grained earthly texture.

2.Shelly limestone:

It has a rich assemblage of fossils that are fully or partly preserved.

3.Argillaceous limestone:

It contains clay as a significant constituent and are clearly of alocathonous origin.

4.Lithographic limestone:

These are compact massive homogenous varieties of pure limestone's that find extensive use of in litho printing.

6. Difference Between the Conglomerate and Breccias (AUC NOV/DEC 2011)

Breccias:

It is a mechanically formed sedimentary rock. It consists of angular fragments of heterogenic composition embedded in a fine matrix of clayed material.

The angularity of the fragments indicates that these have suffered very little or even no transport after their disintegration from the parent rocks.

Types:

a. Basal Breccias:

This rock is formed by the sea waters advancing over a coastal region covered with fragments of chart and other similar rocks .Once seawater retreats, the loose cherty fragments get cemented together as Breccias rocks

b. Fault Breccias:

These rocks are made up of angular fragments that have been produced during the process of faulting.

Conglomerates :

These are clastic nature and also belong to rudaceous group. They consist mostly of rounded fragments of various sizes but generally above 2 mm.

The roundness of gravels making the rock is a useful characteristic to differentiate it from Breccias in which the fragments are essentially angular.

Types:

There are three types:

i. Basal conglomerates:

Having gravels derived from advancing sea –waves over subsiding land masses.

ii. Glacial conglomerate:

In which gravel making the conglomerate are distinctly of glacis origin.

iii. Volcanic conglomerate:

These are distinct volcanic origins but have subsequently subjected to lot of transport resulting in their smothering and polishing on litho logical basis conglomerates are grouped in two classes.

7. Differentiate Between Black Granite (Dolerite)

(AUCNOV/DEC 2009)

Diorite:

Definition;

It is an intermediate type of igneous rock of plutonic origin with silica percentage generally lying between 52 – 66 %.

Composition:

There are typically rich in feldspar plagiocose of sodic group, diorites also contain accessory minerals like hornblende, biotite and some pyroxenes.

Texture:

In texture, diorites show close resemblance to granites and other plutonic rocks. They are coarse to medium grained and hole crystalline.

Occurrence:

Diorite commonly occurs as small intrusive bodies like dikes, sills, stocks and other irregular masses

8. Define the term metamorphism . Give Examples **(AUC MAY/ JUNE 2010)**

It may define as metamorphic process involving essentially formation of new minerals by the mechanism of chemical replacement of pre-existing minerals under the influence of chemically active fluids

Three major kinds of Metamorphism differentiated on the basis of dominant factors are thermal metamorphism, dynamic metamorphism and Dynamo thermal metamorphism

9. List the Few texture of Igneous Rocks **(AUC MAY/ JUNE 2012)**

The term texture has been defined as the mutual relationship of different mineralogical constituents in a rock. It is determine by size, shape and arrangement of these constituents within the body of rock.

1. Aphaeretic
2. Glassy or vitreous
3. Pyroclasti

4.Phaneritic
5.Pagmatite

10. Distinguish Between Limestone and Shale (AUC MAY/ JUNE 2012)

These are the most common sedimentary rocks from the non clastic group and are composed chiefly of carbonate of calcium with subordinate proportions of carbonate of magnesium.

It is fine-Grained sedimentary rocks of argillary, composition, these are made up of very particle of slit and clay

11. What is mean by Rock?

It is defined as “natural solid massive aggregates of minerals forming the crust of the earth”

12. Define Petrology?

The branch of geology dealing with various aspects of rocks such as their formation, classification and occurrence is called petrology.

13. Give the various types of rocks?

1.Igneous rock
2.sedimentary rock
3.Metamorphic rock

14. What is mean by magma?

The hot molten material occurring naturally below the surface of the earth is called magma.

15. Define Igneous rock?

All rocks that have formed form an originally hot molten material through the process of cooling and crystallization may be defined as Igneous rocks.

16. Distinguish between monomineralic rock and polymineralic rock with Examples?

Monomineralic rock:

Rocks composed by a single mineral (e.g.) pyroxenes which is composed at pyroxene only.

Polymineralic:

Rocks composed at more than one mineral and polymineralized rock (e.g.) Granite.

17. Differentiate: Plutonic rock and volcanic rock?

Igneous rocks which have formed at a depth are known as plutonic igneous rock. (e.g. granite) and those formed from lava and formed mainly at the surface are known as volcanic igneous rock (e.g Basalt)

18.Define Texture of Igneous rock:

The term texture is defined as the mutual relationship of different mineralogical constituents Q is a rock. It is determined by the size, shape and arrangement of these constituents within the body of the rock.

19.Give the categories of Texture:

1. Equigranular texture
2. In equigranular texture
3. Directive texture
4. Inter growth texture
5. Inter granular texture

20.Distinguish between monomineralic rock and polymineralic rock with example:

Monomineralic rock:

Rocks composed by a single mineral (e.g) pyroxenes which is composed of pyroxene only.

Polymineralic rock:

Rocks composed of more than one mineral are polymineralized rock. (e.g) Granite.

21.Define the structure of igneous rock?

These rocks are developed on a large scale in the body of an extrusion or intrusion, giving rise to conspicuous shapes or forms are included under the term structure.

22.What are the various types at structure in igneous rock?

The structures are:

1. flow structure
2. Pillow structure
3. ropy and blocky lava
4. Spherulitic structure
5. Orbicular structure

23.How will you distinguish the three kinds of rocks?

The igneous rocks are characterized by its hard, compact, massive, interlocking and strong structure.

- The sedimentary rocks are characterized by it bedded or layered structure.
- The metamorphic rocks are characterized by its banded or foliated structure.

24.Define Granite

rock It may be defined as plutonic light colored igneous rocks. These are among the most common igneous rocks. The work granite is derived form Latin word geraniums meaning a grain and obviously refers is the equigranular texture of the.

25.What are the various types of sedimentary structure?

Mechanical structure:

i. Stratification or bedding
ii. Lamination and cross bedding
iii. Ripple marks
iv. Rain marks
v. Joints land cracks

Chemical structure:

i. Concretionary structure
ii. Oolitic structure
iii. Geode structure

Organic structure

i. Foot print of animals
ii. Leaf impression of plants
iii. Markings of insects

26.What is mean by faces? And types of faces

The concept of formation of a sedimentary rock is a particular type of environment is explained by the term faces.

Three kinds of faces

1. Continental faces
2. Transitional faces
3. Marine faces

27.What are the factors allowed in texture of sedimentary rocks?

The factors are:

i. Origins of Grains
ii. Size of grains
iii. Shape of grains
iv. Packing of grains
v. Fabric of grains
vi. Crystallization trend

28.Define the following term:

i. Ratites
ii. Arenites
iii. Lutites

Rudites:

There are also called rudaceous and include all coarse grained rocks of heterogenous composition. Rudites are made p of bounders, cobles and Pebbles collectively known as gravels.

Arenites:

These are also called arenaceous rocks. These are made up to sediments of sand grad (2 mm - / 16 mm)

Lutites:

These are also called argillaceous rocks. It may be defined as sedimentary rocks of the finest grains size.

29.Define conglomerates:

These are sedimentary rock at clastic nature and also belong to rudaceous group. They consist mostly of rounded fragments of various sizes but generally above 2mm. Cemented together is clays or mixed matrix.

30.What do you understand by metamorphism?

It may be defined as the response in solid rocks to pronounce charged of temperature, pressure and chemical environment. In other cases metamorphism means the partial or complete crystallization of a rock and the production of new structures.

31.What are the three kinds of metamorphism?

1. Thermal metamorphism
2. Dynamic metamorphism
3. Dynamo thermal metamorphism

32. Explain about Hypabassal Rocks?

These Igneous Rocks are formed at Intermediate depths, generally up to 2 Km, below the surface of earth and exhibit mixed characteristics of volcanic and plutonic rocks. Porphyries of various compositions are example of Hypabassal Rocks.

33. What are the factors Explaining Texture?

a) Degree of Crystallization Holocrystalline, Holohyaline.
b) Granularity Coarse grained, Medium grained, Fine grained.
c) Fabric Panidiomorphi, Allotrimorphic,
Hypidiomorphic.

34. Define Equigranular and Inequigranular Texture?

All those textures in which majority of constituent crystals of rock are broadly equal in size are described as equigranular textures.

All those textures in which majority of constituent minerals show marked difference in their relative grain size are grouped as Inequigranular textures.

35. Define Structure of Igneous Rocks?

Those feature of Igneous Rocks that are developed on a large scale in the body of an extraction or instruction giving rise conspicuous shapes or forms are included under the term structures. They may be so well developed as to be recognized easily on visual inspection or they become apparent only when this section of such rocks is examined under microscope. In latter case they are termed microstructure.

36. What are the numbers of factor depending on Igneous Rocks?

a) The structural deposition of the host rock (also called country rock).
b) The viscosity of the magma or lava.
c) The composition of the magma or lava.
d) The environment in which injection of magma or eruption of lava place.

37. Define Volcanic Necks?

In some cases, vents of quiet volcanoes have become sealed with the intrusion, such instruction are termed volcanic Necks or Volcanic Plugs. These masses may be circular, semicircular or irregular and show considerable variation in their diameter.

38. What are the Structures Sedimentary Rocks?

a) Mechanical Structures
   Stratification, Lamination, Cross Bedding, Graded Bedding, Mud Cracks, Rain Prints, Ripple Marks.
b) Chemical Structure
   Concretionary Structure, Oolitic and Pisolitic Structures, Nodular Structure, Geode Structure.
c) Organic Structures.

39. What is the Classification of Sedimentary Rocks?

a) Clastic Rocks

- Gravels
  Boulders, Cobbles, Pebbles.
- Sands
  Coarse Sands, Medium Sands, Fine Sands
- Silts
- Clays
  Rudites, Arenites, Lutites.

b) Non Clastic Rocks

- Chemically formed rocks
  Siliceous Deposits, Carbonate Deposits, Ferruginous Deposits, Phosphate Deposits, Evaporates.
- Organic Deposits

c) Miscellaneous deposit

40. Explain metamorphic changes.

All the changes in the body of rocks that are due to variations in the factors of pressure, temperature and chemical environment are know the metamorphic changes and te process itself is termed metamorphism.

41. What are the kinds of Metamorphism?

Three major kinds of Metamorphism differentiated on the basis of dominant factors are thermal metamorphism, dynamic metamorphism and Dynamo thermal metamorphism

42. Define Stress minerals.

Those minerals which are produced in the metamorphic rocks chiefly under the influence of factor are known as stress minerals.

43. Define Slate?

Slate is an extremely fine grained metamorphic rocks characterized by a slate cleavage by virtue of which it can be split in to thin sheets parallel smooth surfaces, The salty cleavage is due to parallel arrangement of platy and flaky operating during the process of metamorphism

47. Define Schist?

Schist is megascopic ally crystalline metamorphic rocks characterized by typical schistose structure. The constituent platy and Flaky minerals are mostly arranged in irregular parallel layers or bands

16 MARKS QUESTIONS AND ANSWERS

1. What do you understand by the terms texture is igneous rocks?

It is defined as the mutual relationship of different mineralogical constituents in a rock. It is determined by the size, shape and arrangement of these constituents within the body of the rock.

Factors explaining texture:

The three factors are,

a. Degree of crystallization:

All the constituent minerals may be present in distinctly crystallized forms and easily recognized by unaided eye in non-crystallized form.

i. **Holocrystaline:**
When all the constituent minerals are distinctly crystallized.

ii. **Holohyaline:**
When all the constituents are very fine is size and glassy or non crystalline in nature.

b. Granularity:

This defines the grain size of the various components of a rock. Thus the rock texture is described as:

i. Coarse grained – when the average grain size is above 5 mm the constituent minerals are then easily identified with naked eye.

ii. Medium grained: When the average grains size lies between 5 mm and 1mm use of magnifying less after becomes necessary for identifying all the constituent mineral components diagram.

iii. Fine grained: When the average grain size is less than 1mm. In such rocks identification of the constituent mineral grains is possible only with the help of microscope for which very this rock sections have to be prepared.

C. Fabric:

This is a composite term expressing the relative grain size of different mineral constituents in a rock and well as degree of perfection in the form of the crystals. Fabric will be defined by three terms.

i. **Pando morphic:**
When majority of the components are in fully developed shapes.

ii. **Hypidiomorphic:**

The rock contains crystals of all the categories:

iii. **Allotrimorphic:**
When most of the crystals are of anhedral or irregular shapes.

Types of Texture:

These can be broadly divided into five categories.

- Equigranular texture
- In equigranular texture
- Directive texture
- Intergrowth texture
- Inter granular texture

Equigranular Texture:

All these textures in which majority of consistent crystals of a rock are broadly equal in size. In igneous rocks these textures are shown by granites and felsites are often named as granitic and felsitic textures.

In granitic texture, the constituents are either all coarse grained or all medium grained and the crystals show ethereal to subhedral outlines. In the felsitic texture the rock is micro granular the grains being mostly microscopic crystals but these invariably show perfect outlines.

In equigranular Texture:

The constituent minerals show marked difference in their relative grain size are grouped as in equigranular texture.Porphyritic and policlinic textures are important examples of such textures.

Directive Textures:

These textures that indicate the result of flow of magma during the formation of rock are known as directive texture.

The exhibit perfect parallism of crystals or crystallites in the direction of the flow of magma. Frachytic textures are common examples.

Intergrowth Texture:

During the formation of the igneous rocks two or more minerals may crystallize out simultaneously in a limited space. So that the resulting crystals are mixed up or intergroup. Graphic and granophyres texture is example.

Inter granular Texture:

In certain igneous rock crystals formed at earlier stages may get to arranged that polygonal or trigonal spaces are left in between them. This texture so produced is called an intergranular structure.

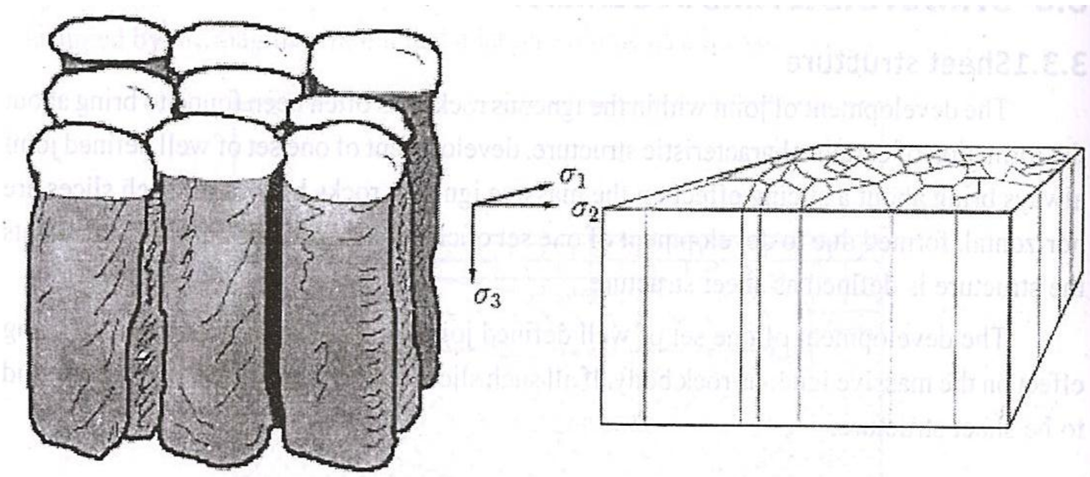
2. Explain briefly about structure and forms of an igneous rock?

1. Structure of Igneous Rocks

These rocks are developed on a large scale in the body of an extrusion or intrusion giving rise to conspicuous shapes or forms are included under the term structures.

Types

Igneous rocks can be broadly grouped under three headings.



a. Structure due to mobility of Magma (or) lava:

The mobility of Magma is responsible for a variety of structures that will acquire.

- Flow structure
- Pillow structure
- ropy and blocky lava
- Spherulitic structure
- Orbicular structure.

Flow structure:

It is defined by the development of parallel or nearly parallel layers or bands in the body of an igneous rock.

Pillow Structure:

This is characterized by the development of bulbous, over lapping, pillow like surfaces in the body of igneous mass. It is typical structure at rocks formed form mobile basaltic lava.

Roby and Blocky lava:

Highly viscas dry lavas undergo very little movement after their eruption and before cooling. Their surfaces show broken and fragmented appearance. These are called blocky lag

The upper surface is smoothly wrinkled rather than actually broken. The surface structure is then referred as nosy lava.

Spherulitic structure:

It is distinguished by the presence of this mineral fibers of various sizes arranged in perfect or semi perfect radial manner about a common centre.

Orbicular structure:

It is a range type of structure of igneous rocks in this a rock mass appears as if composed of ball like aggregations.

Joining structure:

Cooling of magma or lava is very often accompanied by development of cracks or joints in the rocks formed form these sources.

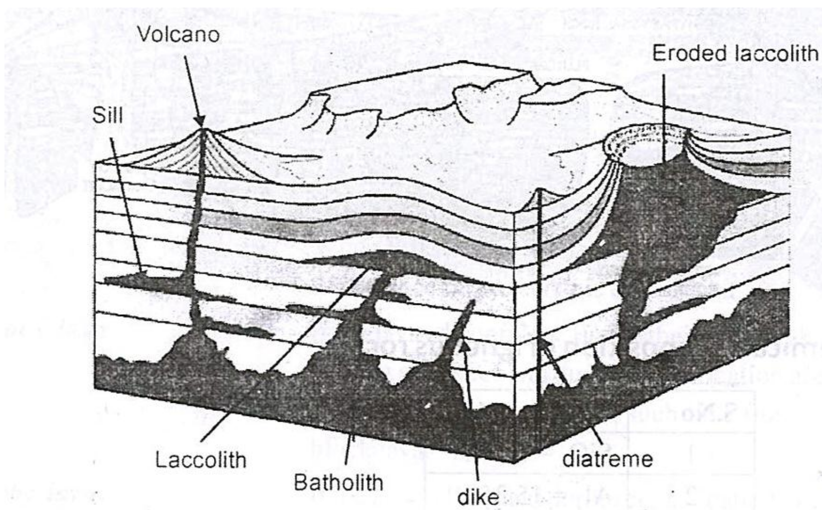
Vesicular structure:

The process of cooling and crystallization is generally accompanied by the escape of these gases. This leads commonly to the formation of cavities of various sizes and shapes in the cooled mass.

2. Forms of igneous rocks

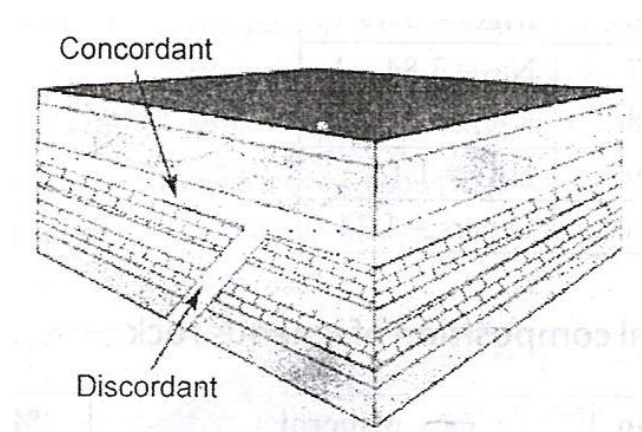
The cooled igneous masses occur is nature in a variety of shapes (or) forms. The igneous mass will acquire on cooling depends on a number of factor such as

a. The structural disposition of the host rock
b. The Viscosity of the magma
c. The composition of the magma
d. The environment of which injection of magma



Concordant bodies:

All those nitrogen in which the magma has been injected and cooled along or parallel to the structural planes of the host rocks are grouped as concordant bodies. Most important concordant forms are sills, batholiths, laccoliths and laccoliths

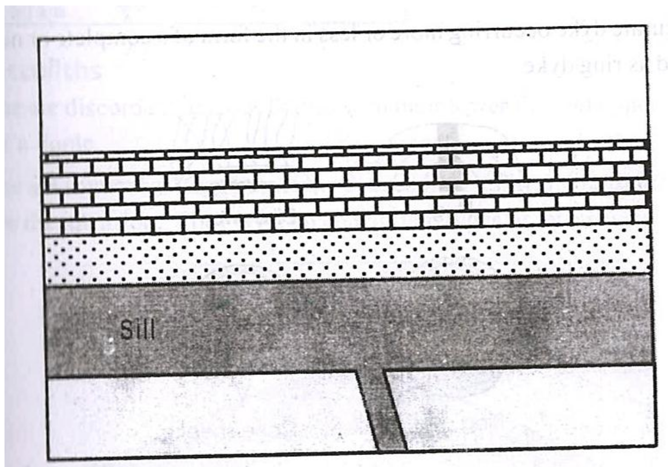


Sills:

These igneous intrusions that have been injected along or between the bedding plane or sedimentary sequence are known as sills. It is typical of sills that their thickness is much small than their width and length.

Sills are commonly subdivided into following types:

a. Simple sills
b. Multiples sills
c. Composite sills
d. Differentiated sills
e. Inter formational sheets

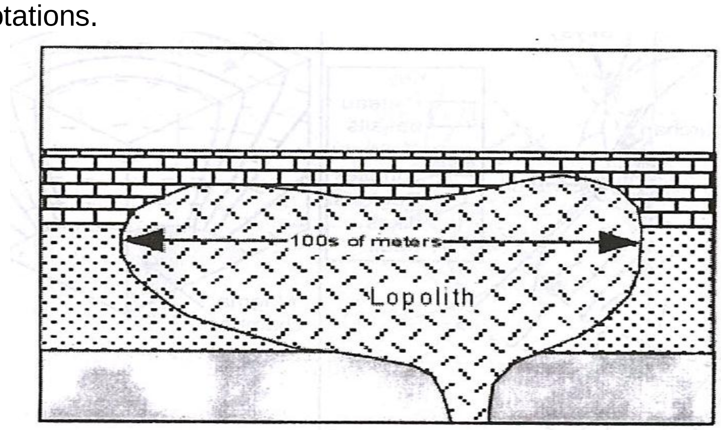


batholiths

These are concordant, small sized intrusive that occupy positions in the through and crests of bends called folds.

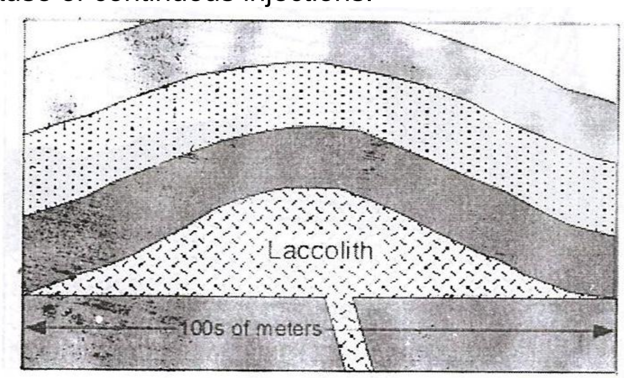
Lopoliths:

These igneous intrusions which are associated with structural basins, that are sedimentary beds inclined towards a common center are termed or Lopoliths. They may from huge bodies of consolidated magma, often many kilometers long and thousands of meters thick. Lopoliths like sills may be simple, complex or differentiated in character the terms having same connotations.



Laccoliths:

These are concordant intrusion due to which the invaded strata have been arched up or deformed into a dome. Lacoliths are formed when the magma being injected is considerably viscous so that it is unable to flow and spread for greater distances. Extreme types of laccoliths are called bysmaliths and in these the overlying strata get ultimately fractured at the top of the dome because of continuous injections.



Discordant Bodies :

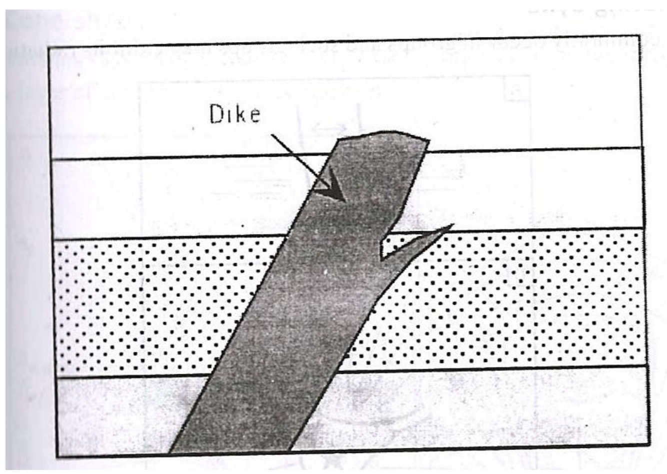
Important types of discordant intrusion are dykes, volcanic necks, and batholiths.

Dykes (Dikes):

These may be defined as columnar bodies of igneous rocks that across the bedding plane (or) unconformities or cleavage planes and similar structures.

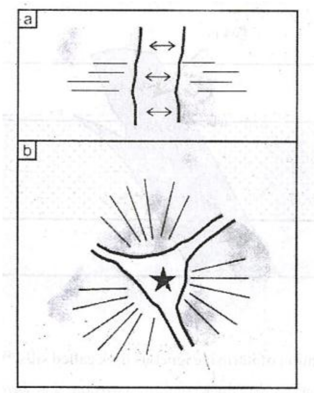
Dykes show great variations in their thickness, length texture and composition. They may be only few centimeters or many hundred of meters thick.

It is customary to classify dykes as simple dykes, multiple dykes, composite dykes, differentiated dykes.

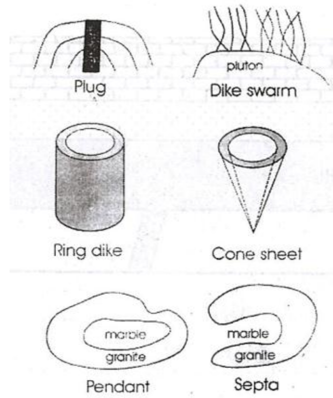


Types of Dykes

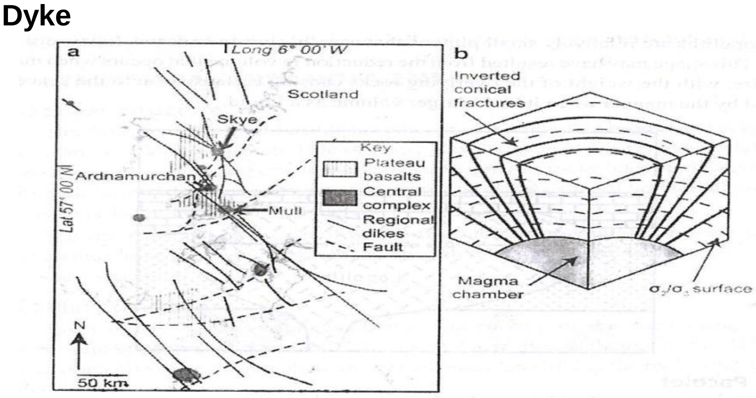
1. Radiation Dyke



2. Ring Dyke



3.Cone Sheet Dyke



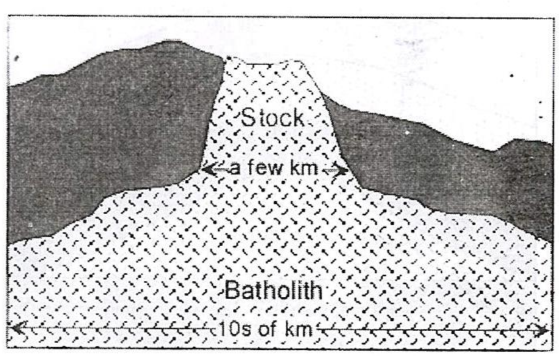
Volcanic necks:

In such congealed intrusions are termed volcanic necks or volcanic plugs. In outline these masses may be circular, semicircular, or irregular and show considerable variation is their diameter.

Batholiths:

These are huge bodies of igneous masses that show both concordant and discordant relations with the country rock.

In composition batholiths may be made of any type igneous rock. They also exhibit many types of textures and structures.



Igneous Extrusions:

The igneous extrusions do not show much complexity in their form. They generally occur as widely speed, extensive flows covering enormous area and the existing toposcraphy. These may be layers other sedimentary materials deposited during the volcanic intermissions which are called inter trapped layers.

3. Write short notes on:

- **i. Granite**
- **ii. Diorite**
- **iii. Syerite**
- **iv. Basalt**
- **v. Gabbro.**

Granite:

It may be defined as plutonic light color igneous rock. The word granite is derived from Latin word granum meaning a grain and refers to the equigranular texture of the rock.

Composition:

Two most common and essential mineral constituents of granites are;

Quartz and Feldspar. Quartz is always recognized by its glassy luxture, high hardness, and cleavage less transparent. Feldspar may be of two varieties. The potash feldspar and soda bearing feldspar.

Texture:

Granites are generally coarse to medium grained, Holocrystaline and equigranular rocks. Granites, graphic, porphyritic and intergrowth texture are the most common types of textures, met with is granites of different varieties.

Types:

Many types of granites are distinguished on the basis of relative abundance is them of some particular accessory mineral.

White mica, muscovite is present as a prominent accessory mineral. The granite may be distinguished as muscovite granite.

Use:

Granite finds extensive use in architectural and massive construction where they are finding in abundance. These rocks have been used extensively in monuments and memorials as columns and steps and as theoring in buildings.

Diorite:

Definition;

It is an intermediate type of igneous rock of plutonic origin with silica percentage generally lying between 52 – 66 %.

Composition:

There are typically rich in feldspar plagiocose of sodic group, diorites also contain accessory minerals like hornblende, biotite and some pyroxenes.

Texture:

In texture, diorites show close resemblance to granites and other plutonic rocks. They are coarse to medium grained and holo crystalline.

Occurrence:

Diorite commonly occurs as small intrusive bodies like dikes, sills, stocks and other irregular masses.

Syenites:

Definition:

These are volcanic rocks in which plagioclase feldspar are the predominant constituents making the potash feldspar only a subordinate member.

Composition:

The most common feldspars of Syenites are orthoclase and alite microcline, Oligoclase and anorthite are also present is then is subordinate amounts.

Texture:

Syenites show textures broadly similar to those of granites, that is they are coarse to medium grained Holocrystaline is nature.

Types:

Few – Well known types of syenites as follows

- **i.)Nordmarkite**: a syenite that contains some amount of quarts in then.
- **ii)Monazite :** Feldspar become almost equal to the potash feldspar as essential minerals.
- **Larvikite:** It is also sometimes known as blue granite, it is however actually a syenite that contains feldspar laboratories as a predominant constituent.
- **Nepheline:** These are a group of syenite rocks in which nepheline becomes an important constituent.

Gabbro

Definition:

These are coarse, grained plutonic rocks of basic character. Plagioclase feldspars, of lime – soda composition are the chief constituents of gabbro's.

Texture:

Gabbro shows variable texture, generally coarse to medium grained, reaction rim structure is seen in some gabbro's.

Types:

i. Norite:

Contains orthomorphic pyroxene like hypersthenes and enstatite in addition to labradorite.

ii. Gabbro

It contains monoclinic pyroxenes as the dominant mafic mineral besides the typical feldspars.

iii. Anorthosite:

It is a typical monomineralic rock containing generally feldspar labrodorite.

iv. Eucrite:

It is a gabbroic rock in which feldspar bytwonite or anorthite dominates.

v. Troctolite:

It is that gabbroic rock which contains mainly feldspars and oliumie.

vi. Dunite:

This gabbroic rock is characterized with the typical absence of felspars and dominance of oliuise and pyroxenes.

Basalts

Definition:

Basalts are volcanic igneous rocks formed by rapid coding from lava flows from volcanoes either over the surface (or) under water on oceanic floors.

Composition:

Basalts are commonly made up of calcic plagioclase felspars and a number of ferro – magnesian minerals like augite, horn blende. In fact many types of basalts are distinguished on the basis of the type and proportion of Ferro magnesian minerals in them.

Occurrence:

The basaltic rocks form extensive lava flows on the continents and also on the oceanic floors in almost all the regions of the world.

4. Explain briefly about Formation and Texture of sedimentary rocks?

Sedimentary rocks are also called as secondary rocks. This group includes a wide variety of rocks formed by accumulation, compaction and consolidation of sediments.

Formation:

The process of formation of sedimentary rocks is ever prevailing. The sediments so produced are transported to the settling basins such as sea floors where they are deposited, get compacted and consolidated and finally transformed into a cohesive solid mass.

Sedimentary rocks are broadly grouped into three classes on the basis of their mode of formation.

- Mechanically formed (or) clastic rocks
- Organically formed rocks
- Chemically formed rocks.

1.Clastic (Mechanically) formed rocks:

a. Decay and disintegration:

The rocks existing on the surface of the earth are exposed to decay and disintegration by the action of natural agencies like atmosphere, water and ice on them.

The original hand and weren't rock bodies are gradually broken down into smaller fragments grains and particles. The disintegrated, loosened material so formed and accumulated near the source is called as detritus. Hence classic rocks are often also called as detrital rocks.

b. Transport of sediments:

The detritus produced from the decay and disintegration of the pro existing rocks forms the source of the sedimentary rocks but it has to be transported to a suitable place for transformation again into a rock mass. The running water bodies transport the sediment load as bed-load, suspended load and dissolved load al dumped at the setting basins.

C. Gradual deposition:

The sediments as produced through weathering and erosion are transported to setting basins. These basins may be located in different environments such as on the continents, along the seashores or in deep or in deep – sea environments. In the continental environments may be included the glacis deposits the fluvial deposit, the glacio fluvial deposits and the eolian deposits each type giving rise to a definite type of sediment accumulation.

d. Digenesis:

The process of transformation of loose sediments deposited in the settlement basins to solid cohesive rock masses either under pressure a. This cementation is collecting known as Diagnosis.

2. Chemically formed (non- clastic) rocks:

Water is a great solvent. Water from rains, springs streams, rivers, lakes and underground water bodies dissolves many compounds from the rocks with which it comes into contact.

In all cases a stage may be reached when the dissolved salts get crystallized out either through evaporation or through precipitation.

Rock salt may be formed form sodium chloride rich seawater merely by the process of continued evaporation in bays and lagoons.

C. Organically formed rocks:

These extensive water bodies sustain a great variety of animal and plant life. The hard parts of many sea organisms are constituted chiefly of calcium and magnesium. Limestone's are the best examples of organically formed sedimentary rocks.

Environment of formation:

Facies:

The concept of formation of a sedimentary rock in a particular type of environment is explained by the term facies. There are three main facies a sedimentary rock.

a. Continental facies:

Sedimentary rocks formed on the continents such as in lakes, rivers, streams, and alluvial fans are said to belong to the continental facies. Coarse grained rocks like breccia, Conglomerates and soft sand stone are typical examples of rocks of continental facies.The rocks of continental facies are, in general relatively less dense, loosely packed, and often cemented.

b. Transitional facies:

Some sedimentary rocks may be formed by accumulation and composition of sediments along the seashore or on the continental shelt that remains partly submerged under sea such an beaches and deltas. These sediments and rocks developed from the represent the transitional facie

C .Marine fancies:

All sedimentary rocks formed at sea floor and ocean floors are covered under marine facies. These may be further subdivided in shallow sea deposits and deep marine deposits formed on ocean floors.

Textures of sedimentary rocks:

This texture is determined by at least six contributing factors.

i. Origin of Grains:

A sedimentary rock may be partially or wholly composed of clastic grains, or of chemically formed or organically contributed parts. Thus the rock may show a clastic texture or an on clastic texture.

ii. Size of Grains

The grain size in the sedimentary rock varies within wide limits. Three textures recognized on the basis of grain size are:

Coarse grained rock	**-**	**average grain size > 5 mm.**
Medium grained rock	**-**	**average grain size between 5 and 1 mm**
Fine grained rock	**-**	**average grain size < 1mm.**

iii. Shape of Grains

The sediments making the rocks may be of various shapes, rounded surrounded, angular and sub angular.

iv. Packing of Grains:

Sedimentary rocks may be open packed or porous in textures or densely packed depending upon their environment of formation. The degree of ___ is generally related to the load of the overlying sediments during the process of deposition.

v. Fabric of grains:

It may contain many elongate particles. Their orientation is studies and described in terms of orientation of their longer axes.

5). Explain classification of sedimentary rocks giving suitable examples?

It has been variously classified on the basis of their mineralogical composition, environment of deposition, mode of formation and textural and structural features.

There are two main divisions:

1) Clastic
2) Non-clastic

1. Clastic rocks:

These are also called mechanically formed rocks and include all those sedimentary rocks that have been formed from pre existing rocks by operation of fine process.

1. **Weathering**
2. **erosion**
3. **transport**
4. **deposition**
5. **digenesis'.**

The gravels, sands, stales and clays are further classified to grain size in following manner.

a.Gravels:

All sediments and clastic fragments of rocks above the size of 2mm irrespective of their composition and shape are broadly termed as gravels.

b.Sands:

All sediments that lie within the size range of 2 mm and $1/16$ mm are grouped as sands petrologic ally the term is generally used for silica's sediments. It may be further divided into three sub groups.

1. Coarse sands
2. Medium sand
3. Fine sand

C.Silts:

These are very fine sized particles of varying composition lying in the range between $1/16$ mm and $1/256$ mm. The silts are the major continents of rocks known as shales.

d.Clays:

All particles finer is size than $1/256$ mm are commonly referred to as clays. They are minerals formed in a variety of ways and abound in nature both as soils and rocks as clay stone, mudstones and shales etc.

B.non clastic rocks:

This group includes all those sedimentary rocks that have been formed by anyone of following two processes.

1.Operation of simple chemical process:

Such as evaporation, precipitation and crystallization at ordinary temperature and pressure from natural solution in different environments.

2.Accumulation of hard parts of organism:

It remains lot plant life followed by their compaction and consolidation.

A. Chemically formed rocks:

On the basis of their chemical composition, these rocks are further sub-divided into following groups.

i. Siliceous Deposit:

In silica is the chief constituent. Some forms of silica like chalcedony and opal are slightly soluble in water. When solutions saturated with this type of silica enter environments where evaporation is possible, deposits of siliceous masses are made.

Example: flint, cherty, jasper.

ii. Carbonate deposits:

These are precipitated from carbonate rich waters under different conditions that control the concentration of carbon dioxide.

iii. Ferruginous Deposits:

Oxides and hydroxides of iron are common examples of chemically precipitated iron deposits.

iv. Posphatic deposits:

These are mostly from sea waters rich in phosphoric acid.

B. Organic deposits:

Following types of organic deposits are distinguished on the basis of their chemical composition.

i. Carbonate Rocks:

A great part of the limestone's found in different areas of the world is actually marine and organic in origin.

ii. Carbonaceous rocks:

Sedimentary rocks rich is carbons are called as carbonaceous rocks. In their formation the source material for carbon is mainly derived from plants. Coals are also carbonaceous materials in their first stage of formation.

iii. Ferruginous deposits:

In many fresh water takes and also in swamps some bacteria are thought to be responsible for reduction of ferric oxide to ferrous oxide and finally to its precipitation as iron carbonate.

6. Write short notes on:

- **i. Breccias**
- **ii. Conglomerate**
- **iii. Sand stone**
- **iv. Lime stone**

Breccias:

It is a mechanically formed sedimentary rock. It consists of angular fragments of heterogenic composition embedded in a fine matrix of clayed material.

The angularity of the fragments indicates that these have suffered very little or even no transport after their disintegration from the parent rocks.

Types:

a. Basal Breccias:

This rock is formed by the sea waters advancing over a coastal region covered with fragments of cherty and other similar rocks .Once seawater retreats, the loose chert fragments get cemented together as breccias rocks.

b. Fault Breccias:

These rocks are made up of angular fragments that have been produced during the process of faulting.

Conglomerates :

These are clastic nature and also belong to rudaceous group. They consist mostly of rounded fragments of various sizes but generally above 2 mm.

The roundness of gravels making the rock is a useful characteristic to differentiate it from breccias in which the fragments are essentially angular.

Types:

There are three types:

i. Basal conglomerates:

Having gravels derived from advancing sea –waves over subsiding land masses.

ii. Glacial conglomerate:

In which gravel making the conglomerate are distinctly of glacid origin.

iii. Volcanic conglomerate:

These are distinct volcanic origins but have subsequently subjected to lot of transport resulting in their smothering and polishing on litho logical basis conglomerates are grouped in two classes.

a. Oligomicitic:

Simple in composition, these gravels are made up of quarts, chert and calate.

b. Polymictic:

In this constituent gravels re derived from rocks a all sorts. Igneous, sedimentary, metamorphic all cemented together.

Sand stores:

These are mostly composed at sand grade particles that have been compacted and consolidated together in the form of beds in basins of sedimentation.

Composition:

Quartz (SiO_2) is the most common mineral making the sand stones. Beside, quartz, minerals like feldspars, micas, garret and magnetite may also be found is small proportions in much sandstone.

Texture:

Sand stones are in general medium to fine gravised in texture. The individual grains may be round or angular in outline, loosely packed or densely passed and in sample or interlocking arrangement.

Colour:

Sandstones naturally occur in a variety of colors, red, brown, grey and white being the most common colors.

Types:

Following types are of common occurrence.

i. Siliceous sand stones:

Silica (SiO_2) is the cementing material in these sand stones. Tis is named Quartzite.

ii. Calcareous sand stones:

Those varieties of sandstones in which carbonates of calcium and magnesium are the centering materials.

iii. Argillaceous sandstones:

These are among the soft varieties of sandstone because the cementing material is clay that has not much inherent strength.

Lime stones

Definition:

These are the most common sedimentary rocks from the non clastic group and are composed chiefly of carbonate of calcium with subordinate proportions of carbonate of magnesium.

Composition:

Pune limestone is invariably made up of mineral calcite ($CaCO_3$). In the limestone rock formations, however, presence of dolomite $CaMg(CO_3)_2$, quartz, (SiO_2) feslpar minerals and Iron Oxide is rather a common feature.

Texture:

The most important textural feature of limestone's in their fossiliterous nature. Other varieties of limestone's show dense and compact texture. Some may be loosely packed and highly porous. Others may be compact and homogenous.

Types:

Following are common types of limestone's:

1. Chalk:

It is the purest form of limestone characterized by fine grained earthly texture.

2. Shelly limestone:

It has a rich assemblage of fossils that are fully or partly preserved.

3. Argillaceous limestone:

It contains clay as a significant constituent and are clearly of alocathonous origin.

4. Lithograpic limestone:

These are compact massive homogenous varieties of pure limestone's that find extensive use of in litho printing.

7. Explain briefly about factors and effects metamorphism?

Metamorphic charges in the rocks are primarily the result of three main factors that are also sometimes called as agents of metamorphism.

Temperature:

Rocks are made up of minerals that are normally stable at temperatures below 200^0 C. Two common sources of heat for such a metamorphism to take place are the internal heat and the magnetic heat. The internal heat becomes operative when rocks formed at surface, are pushed downwards due to some geological process, where process, where they have to withstand much higher temperature.

It is believed that most metamorphic changes induced by the heat factor take place between 300^0 - 850^0 C.

Pressure:

Many metamorphic changes are induced solely due to pressure factor whereas in great majority of cases pressure is the dominant factor and is assisted considerably by the heat factor.

The rock at some depth below the surface is subject to pressure from two sources. First load of the overlying burden and second crystals movements during the convergenic of the tectonic plates.

The first type of pressure acts generally in a vertical direction and the process of change in the structure of the rock is often referred as load metamorphism.

The pressure form organic activity is generally lateral or horizontal and is commonly termed as directed pressure.

Chemical environment:

Presence or absence of chemically active fluids within the body the rocks or around them plays very important role in the process of all types of metamorphism. With the rise in temperature, the pore fluids undergo expensing and become very active in disturbing or even breaking the original crystal boundaries of the involved materials. This process is called recrystallization that takes place essentially in a solid state.

Effects of metamorphism:

This depends primarily on following two major factors.

1. The type of rock involved in the process.
2. The kind of metamorphic process operating on those rocks.

The metamorphic process may be one or more of the following main categories.

i. Recrystallization, rock flow age, granulation and metasomatic replacement.

Recrystallization:

In such cases following conditions control the extent of recrystallization.

a) **The size of the igneous intrusion**, or the lava and also its rate of cooling.

b) **The nature of magma or lava** – magmatic melts rich in chemically active fluids will induce a greater degree of recrystallization as compared with those which are poor.

c) **The nature of rock-** It is the single most important factor is that the same rock under different conditions may suffer different set of changes during the process of recrystallization.

Rock flowage:

It is understood actual movement and reorientation of the mineral constituents of rock under the loads acting during the e metamorphic process.

The term should not be taken to given the impression that rocks change their physical state and start flowing when subjected to pressure.

Rock flowage is believed to be a common process of greater depths near the roots and walls of magmatic boundaries and also among margins of tectonic plates.

Granulation:

The influence of dominant stress rocks develop granulation which signifies the birth of very fine fractures within the body of rock involving even the individual minerals.

Granulation is favored by hard and insoluble character of the constituent minerals as well as by higher confining pressures.

Metasomatic Replacement:

It is defined as a process of simultaneous replacement at atomic level by which minerals of a rock are charged into other minerals by addition subtraction of atoms under the influence of chemically active fluids from the surrounding environment. The process may involve exchange of addition, to or expulsion of metallic or non-metallic compounds from an original rock..

When the attacking fluids are vaporous state, the process is distinguished as prevatolytic metasomatism or simply as pneumatolysis.

The original granite rock is thus charged met somatically into tourmaline granite or into a school rock.

When a granite rock is attacked by steam and fluorine vapors only, feldspars are altered to lithium mica and the new rock is called greisem.

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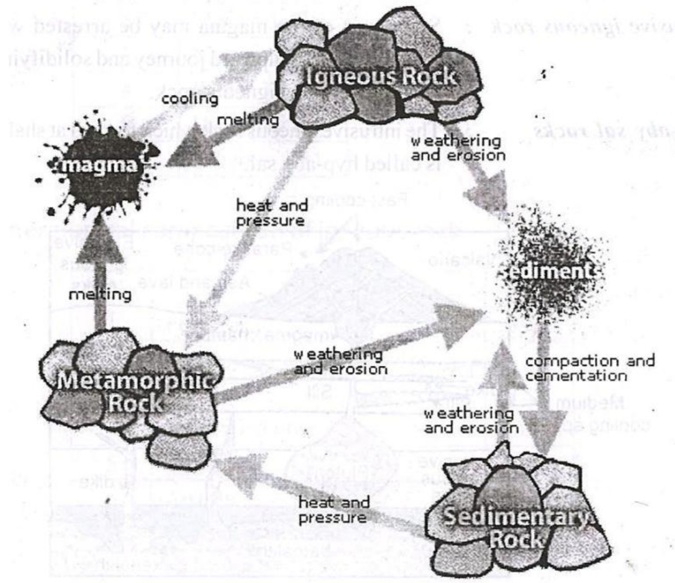
Rock flowage is believed to be a common process of greater depths near the roots and walls of magmatic boundaries and also among margins of tectonic plates.

Granulation is favored by hard and insoluble character of the constituent minerals as well as by higher

8. What is meant By Igneous Petrology. Discuss the Various Formation Stages involved in the Igneous Rocks

The rocks that Have been Formed From an Original Hot, molten material through the process of cooling and Crystallization are Defined as Igneous Rocks



Various Formation Stages Involved in Igneous Rocks

Magma
↓
Lava
↓
Block- Lava
↓
Roby Lava
↓
Extrusive Igneous Rock
↓
Intrusive Igneous Rock
↓
Hyp- aby Sal Rock

1.Magma

The hot molten material occurring beneath of the Crust of the earth is called Magma

2. Lava

When this Magma comes out from the earth interior to the Surface of the Earth is called Lava

3.Block Lava

If the lavas do not Flow, Due to their remarkable viscosity to great distance and during solidification are formed to often a very rough Surface. Such lava flow is called Block lava

4.Roby lava

If the lava is a Fluid and During consolidation the flow offer a Smooth Surface is called as Roby Lava

5.Extrusive Igneous Rock

During their Journey it comes it comes on the earth , the flow offer and Solid to form is called Extrusive Igneous Rock

6. Intrusive Igneous Rock

Some part of the Magma may be arrested with in the Crust during their upward journey and Solidifying to Form it is called Intrusive Igneous Rocks

7. Hyp- aby Sal Rock

The intrusive Igneous Rocks which formed at Shallow depth is called Hyp- aby Sal Rock

DEPARTMENT: CIVIL ENGINEERING
SEMESTER: III
SUBJECT CODE / Name: AG 2211 / Applied geology

UNIT 4 TWO MARKS QUESTIONS AND ANSWERS

1. **Define Dip?**

The inclination of the bedding planes, with the horizontal, is called dip and is always expressed in degrees.

2. **Explain true dip?**

It is the maximum inclination of bedding planes with the horizontal, or in other wards it is the inclination of the direction of which water would flow, if poured on the upper surface of the bed .

3. **Explain apparent dip?**

The inclination of the bedding planes, with the horizontal, in any other direction, other than the direction of the true dip, is know as the apparent dip. The value of apparent dip is always less than the true dip.

4. **Define strike?**

It is the direction, measured on a Horizontal surface, of a line formed by the intersection of dipping bed with the horizontal plan. It is always expressed in terms of main direction ie, is North, South, East or West.

5. **What is mean by folds?**

The earth's crust is tilted out of the horizontal and is bent into folds. Such a fold may ranges from a microscopic crinkle to great arches and troughs even up to 100 kms across. A set of such arches and troughs is called a fold.

6. **What is mean by Anticline and Syncline?**

When the beds are unfolded in an arch-like structure, it is called an anticline. When the beds are down folded in trough like structure, it is called a Syncline. It may be noted that in an anticline the oldest rock is in the centre, where as in a syncline the youngest rocks is in the centre.

7. **Explain Causes of folding?**

The interior of the earth is getting cooler and cooler day by day, which is sure to cause some shrinkage in the earth's crust. This stink age is responsible for the compressive and shearing stress to be developed within the earth's crust. Some time these stresses are small in magnitudes but go on exerting pressure for a sufficient length of time and result in buckling or folding of the layers of the earth's crust.

8. **What are types of folds?**

a) Symmetrical fold
b) Asymmetrical fold
c) Overturned fold
d) Isoclinal fold
e) Recumbent fold

f) Plunging fold
g) Open fold
h) Closed fold
i) Anticlinorium
j) Synclinorium
k) Dome
l) Basin
m) Nonoclinal fold.

9. Define Faults?

Faults are fractures, along which the movement of one block with respect to other, has taken place. This movement may vary from a few centimeters to many kilometers depending upon the magnitude of the stresses, and the resistance offered by the rocks.

10. Explain the Causes of Faulting?

The interior of the earth becoming cooler day by day, which is sure to cause some shrinkage in the earth's crust. This stink age is responsible for the stress to be developed within the earth's crust. These stresses, when greater in magnitudes exert so much pressure that the layers of the earths crust are fold due to compressive stresses and after wards when the stresses are released, fractures are formed. If the stresses still continue, the blocks move up or down along the fault plane depending upon the direction of stresses and their intensity. Such a fracture, along which a movement has taken place, is called a fault.

11. What are the classifications of faults?

Faults are classified on the basis of their apparent displacement, ie, the direction of movement, of one block, with respect to the other along the fault plane.

12. What are the criteria for the recognition of a fault?

1) Discontinuity of strata
2) Repetition and omission of strata
3) Physiographic features
4) General.

13. What is mean by Joints?

When sufficient tensile stress in developed between two successive points, a crack is developed at right angle to the direction of the stress, such cracks are called joints.

14. What is mean by Master joints?

The joints always occur in sets and groups. A set of joints means, joint occurring in the same dip or strike. A group of joints means a few sets of joints having almost the same trend. If a few sets or groups of joints appear for a considerable length in a rock, such joints are called major joints or master joints.

15. Define out crop?

A little consideration will show that the out crop of a rock is affected by the angle of dip also. If a rock has a vertical dip then the outcrop will be less, than that when the same rock is dipping at some angles.

16. What are the different forms of out crops?

a) Out lier
b) In lier
c) Unconformity d) Overlap
e) Cross bedding.

17. Define over lap?

An over lap is particular type of an unconformity, in which the overlying strata extends so as to over lap the underlying strata.

18. Define cross bedding?

Sedimentary beds or layers are generally parallel to one another. But, sometimes, it has been observed that the beds lie slightly oblique to the major bedding planes.

19. What are the classifications of joints?

a) Geometrical classification
Strike joints, Dip joints, Oblique joints b) Genetic classification
Tension joints, shear joints

20. What are the methods of Geophysical Exploration?

Depending upon the type of energy field used, the following methods may be used. Seismic method, Electrical method, Gravitational method, Magnetic method, Radiometric method, Geothermal method.

21)Define mural jointing.

In granitic an other rock masses there ma occur three sets of joints in such a way that one set is horizontal and the other two sets are vertical. All the three sets being mutually at right angles t each other. This sort of geometrical distribution of joints dividing the rock mass into cubical blocks or murals is called mural jointing.

22) State the different types of electrode configurations used in resistivity method.

There are two types of electrode configurations used in resistivity method

Wenner resistivity method:

The electrodes spacing are same distance ie, current electrode to potential electrode and potential electrode to potential electrode at equal distance.

Schlumberger's method:

The inner electrodes are constantly inserted in the ground and the outer current electrodes are changed according to our requirement of depth.

23) Write short notes on shear joints.

These are commonly observed in the vicinity of fault planes and shear zones where their relationship with shearing forces in clearly established. In folded rocks these are located in axial regions. In the core regions of folds where compressive forces are dominant, jointing may be related to the compressive forces.

24) Differentiate between Normal Fault and Reverse Fault.

Normal Fault:

A fault, in which the hanging wall has apparently come down with respect to the foot wall, is known as normal fault.

Reverse Fault:

A fault in which the hanging wall has apparent gone up with respect to the foot wall is known as a reverse fault.

25) What are the types of seismic methods and give their uses?

There are two methods:

i)Reflection survey used for determining rock structures and for deep exploration
ii)Refraction survey used for determining the structure of rocks lying at relatively shallow depth.

16 MARKS QUESTIONS AND ANSWERS

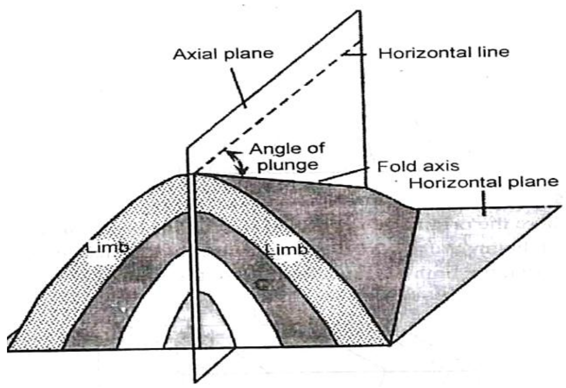
1.What is meant by folding. Explain the various types of folds with neat sketch

Definition:

When rocks deform in a ductile manner, instead of fracturing to form faults, they may bend or fold and the resulting structures are called folds. Folds result from compression stresses acting over considerable time. Because the strain rate is low, rocks that we normally consider brittle can behave in a ductile manner resulting in such folds.

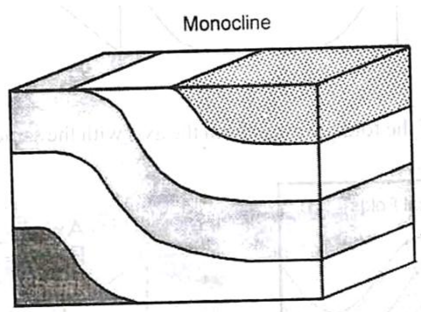
Geometry of Folds - Folds are described by their form and orientation. The sides of a fold are called limbs. The limbs intersect at the tightest part of the fold, called the hinge.

A line connecting all points on the hinge is called the fold axis. In the diagrams above, the fold axes are horizontal, but if the fold axis is not horizontal the fold is called a plunging fold and the angle that the fold axis makes with a horizontal line is called the plunge of the fold. An imaginary plane that includes the fold axis and divides the fold as symmetrically as possible is called the axial plane of the fold.



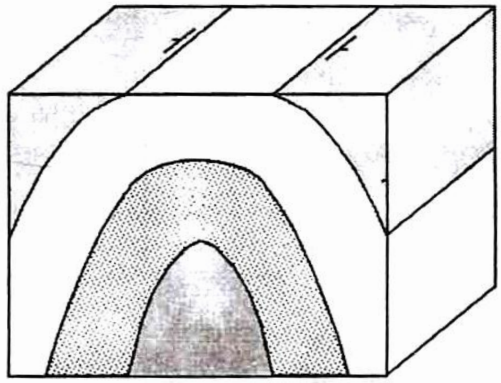
1 Monoclines

Are the simplest types of folds. Monoclines occur when horizontal strata are bent upward so that the two limbs of the fold are still horizontal.



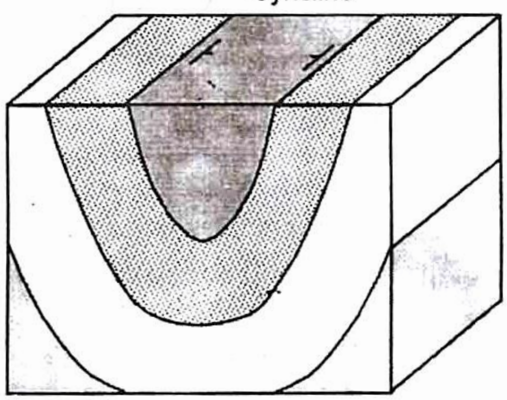
2 Anticlines

Are folds where the originally horizontal strata has been folded upward, and the two limbs of the fold dip away from the hinge of the fold.



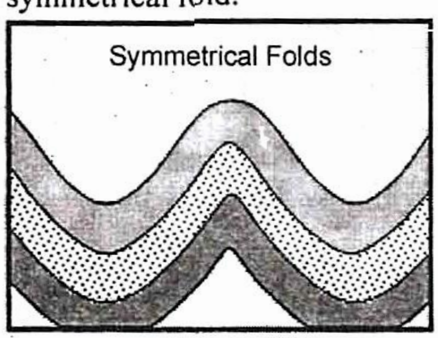
3 Synclines

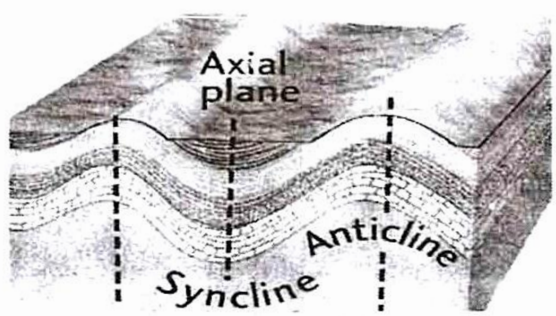
Are folds where the originally horizontal strata have been folded downward, and the two limbs of the fold dip inward toward the hinge of the fold Synclines and anticlines usually occur together such that the limb of a syncline is also the limb of an anticline.



4 Symmetric

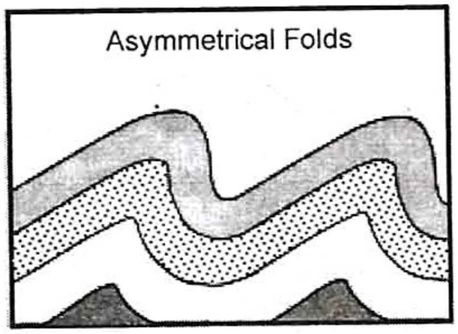
If the two limbs of the fold dip away from the axis with the same angle, the fold is saic to be a symmetrical fold.

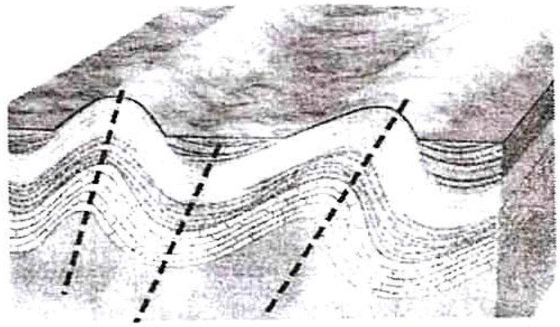




5 Asymmetrical

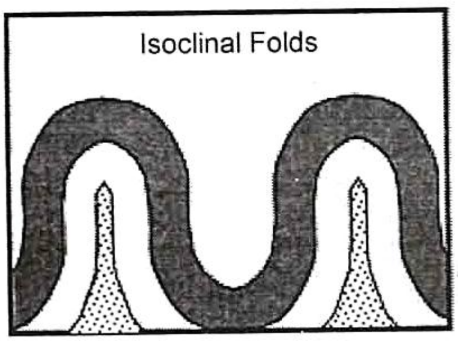
If the limbs dip at different angles, the folds are said to be asymmetrical folds.

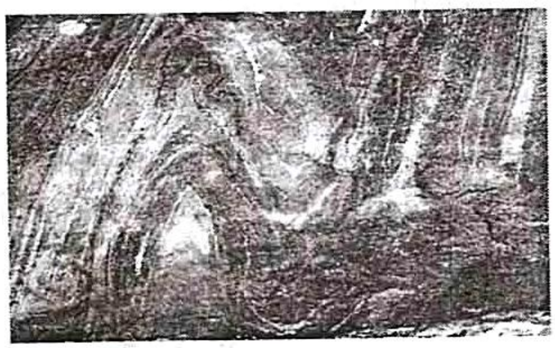




6 Isoclinal

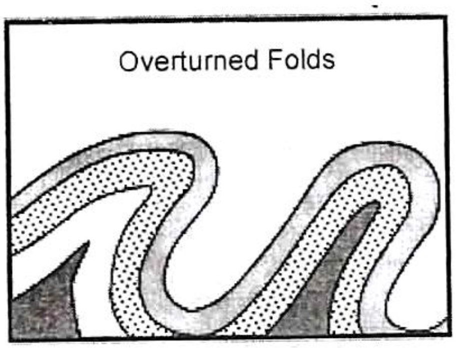
If the compression stresses that cause the folding are intense, the fold can close up nd have limbs that are parallel to each other. Such a fold is called an isoclinal fold iso means ame, and cline means angle, so isoclinal means the limbs have the same angle.

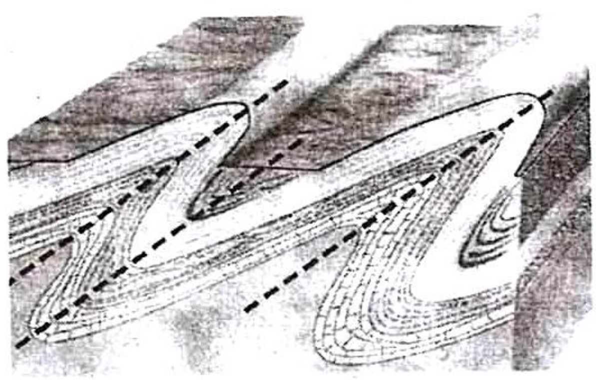




7 Overtune

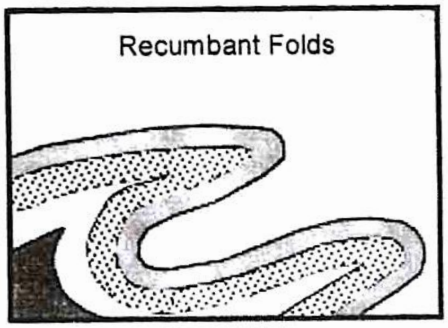
If the folding is so intense that the strata on one limb of the fold becomes nearly upside lown, the fold is called an overturned fold.

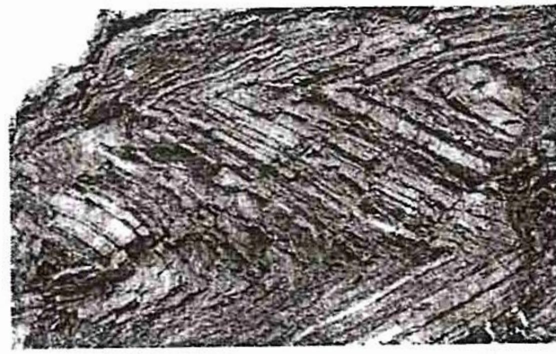




8 Recumbent

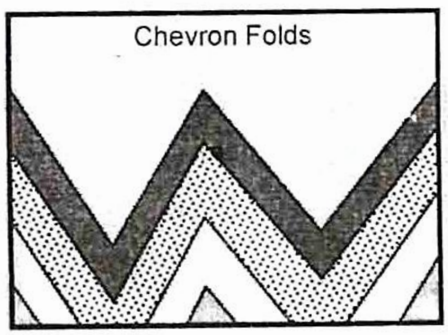
An overturned fold with an axial plane that is nearly horizontal is called a recumbent fold.





9 Chevron

A fold that has no curvature in its hinge and straight-sided limbs that form a zigzag pattern is called a chevron fold.

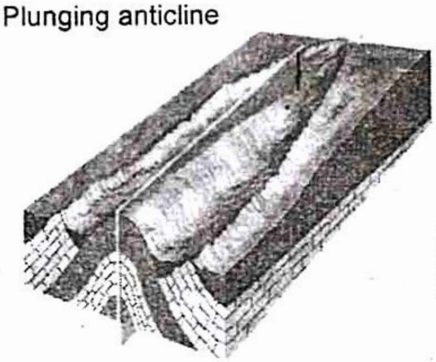


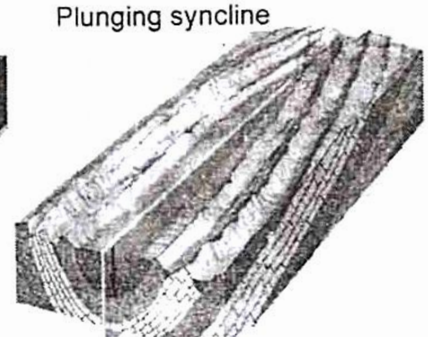
10 Plunging fold

Any fold with the axis not parallel to the planar horizontal is called as plunging fold anc the angle it makes with the plane is called as plunging angle.

Based on the plunging angle it is of two types

- Plunging anticline
- Plunging synclinal





2) Describe the various characteristics in fault?

There are some salient displacements characters are shown as seen in vertical cross section of the involved region.

Fault Plane:

The surface along which the fracture occurs in faulting in a rock mass and relative displacement of blocks takes place is generally a planer discontinuity and is termed as Fault plane. It may be inclined, vertical or horizontal. On the ground surface the fault plane appears as the fault trace-which may or may not be associated with a fault scrap or slope.

Fault Zone:

In many cases the fault is clear-cut discontinuity dividing the original rock mass into two well defined blocks that get displaced along it. In many other cases however a small region may be fractured and displaced along numerous closely spaced and more or less parallel faults. In such cases it is customary to classify the whole tabular fault infested and effected rock zones as a fault zone.

Shear Zone:

This term implies like fault zone a tabular zone of rock that has suffered intense displacement. In shear zones displacement is confined generally to zones of weak materials which are interbedded with rocks of component or strong character.

Dip and Hade

Fault planes may be vertical, inclined or horizontal. The dip of the fault plane is its inclination with the horizontal and is measured both in terms of degree of inclination and direction of inclination. The strike of the fault is the bearing or geographical direction of the line of intersection of a horizontal plane.

The Walls

In any given body of rock, a fracture will naturally result in two parts or blocks. These blocks are often referred as walls, especially when the fault plane is inclined at an angle other than vertical.

Slip and Separation

Faulting involves as is clear from definition relative displacement of blocks of the same rock which were formerly contiguous. There are two general terms to express the nature and magnitude of such a displacement.

Slickenside

It is sometimes used to express displacement in layered rocks which are in their normal order of superposition. It denotes as usual the vertical component of dip separation measures between two points of the same layer that were formerly in contact with each other.

Gouge, Fault Breccias

Rubbing and shearing of blocks during faulting often or near the base of the faults zones. It is obviously the result of strong rubbing action on the rocks during the faulting process.

Fault Breccias

It is the crushed angular, fragmentary material produced during faulting and found in some cases at or near the base of the up thrown block.

Mylonite

This rock also called micro breccia.is extremely fine grained and vary hard and coherent. Faulting is believed to be the cause of development of

3) Explain briefly about Origin and occurrence of joints?

Origin of joints

Joints are caused in different rocks due to different reasons. The joints ma be caused in different rocks. These are outlined as follows:

Contraction during Formation

The plastic nature and rich in moisture in the initial stages undergo some contraction on dying up which might have resulted into irregular jointing. The igneous rocks which form by cooling and crystallization from an originally hot and molten material also necessarily undergo considerable contraction during the cooling process giving rise to tensile forces strong enough to break the masses into jointed rocks.

Expansion and contraction

The repeated expansion and contraction is characteristic of regions with dry hot climates where day and night temperatures on the one hand and summer and winter temperatures on the other hand vary within a very wide range 50^0 to 60^0c. These stresses are compression tension in nature. Joints may appear parallel to the surface of erosion in such exposed rocks. The sheet joints of sedimentary and other rocks are attributed by many to the erosion unloading through geological ages.

Crustal Disturbances

Many joints especially those associated with folded and faulted rocks are clearly related to processes of crustal disturbances that are responsible for building of mountains and continents. These process are easily capable pf exerting sustained and strong forces on rocks that virtually into slices along certain directions irrespective of the composition and strength of the rock components.

Occurrence of joints

Joints are perhaps the most common structural features of all types of rocks. It is seldom that we may find any big rock mass on the surface free from joints. There are three main categories in show joints of various types.

Igneous rocks

The three regular or systematic types of joints observed in igneous rocks are:

Sheet joints

In granites and other related igneous rocks, a horizontal set of joints often divided the rock mass in such a way as to give it an appearance of a layered sedimentary structure called in this case as a sheeting structure.

Mural jointing

In granitic and other roc mass there may be occur three sets of joints in such a way that one set is horizontal and the other two sets are vertical. All the three sets being mutually at right to each other. This sort of geometrical distribution of joints dividing the rock mass into cubical blocks or murals is called mural jointing.

Columnar jointing

This type of joints typical of volcanic igneous rocks although the may also be observed in other rocks. These are also called prismatic joints. The joints divide the roc mass into polygonal blocks, each block being bounded by three to eight sides. In surface area also the blocks may vary from a few centimeters to a couple of meters.

Sedimentary rocks

Most sedimentary rocks are generally jointed. Joints may be of systematic and nonsystematic classes. This joint ma be closely and regularly spaced sets, parallel or sub parallel to each other and bearing varying relationships with the attitude of the rocks. Since sedimentary rocks are often folded and faulted. In deeply stratified rocks removal of overlying strata due to weathering gives rise to compression tension forces that may cause regular and irregular jointing of various types.

Metamorphic rocks

These roc types are heavily jointed in many cases but in most cases the joints are of irregular or non systematic types. These joints are often the result of local and regional stresses acting on rocks as a source of metamorphism. In many cases the metamorphic rocks may show those joints which were pre existing at the time of metamorphism of the rock with little or no modification

4.Enumerate the various types of fault with neat sketch

A fault is a crack in the earth crust. Typically faults are associated with the between the boundaries between the tectonic plates. In an active fault the piece of the earth crust moves along with the fault. Inactive fault had movement along them at one time but no longer.

Types of Faults

Faults can be divided into several different types depending on the direction of relative displacement. Since faults are planar features, the concept of strike and dip also applies, and thus the strike and dip of a fault plane can be measured. s

1 Dip Slip Faults

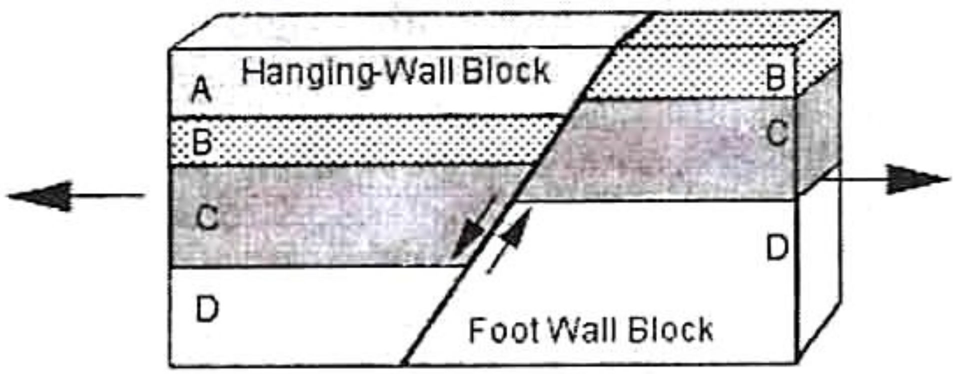
Dip slip faults are faults that have an inclined fault plane and along which the relative displacement or offset has occurred along the dip direction.

Note that in looking at the displacement on any fault we don't know which side actually moved or if both sides moved, all we can determine is the relative sense of motion.

For any inclined fault plane we define the block above the fault as the hanging wall block and the block below the fault as the footwall block.

2 Normal Faults

Are faults that result from horizontal tensional stresses in brittle rocks and where the hanging-wall block has moved down relative to the footwall block.

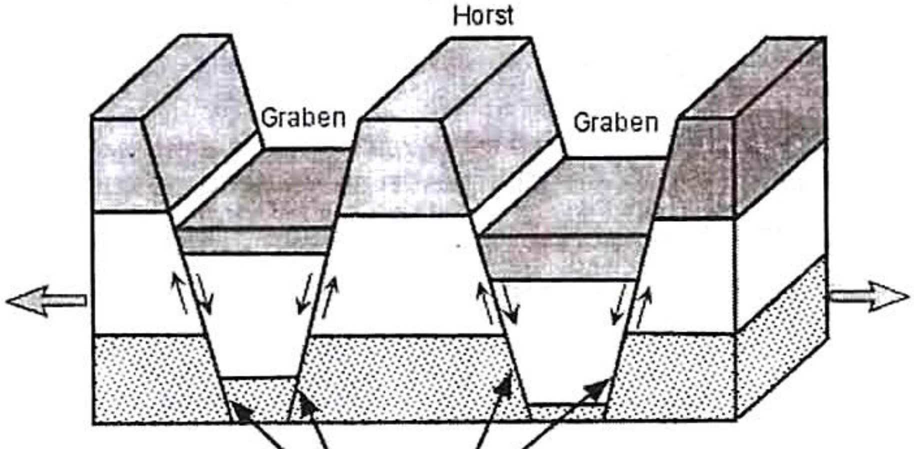


Normal Fault
Extensional Stress

A) Horsts and Grabens

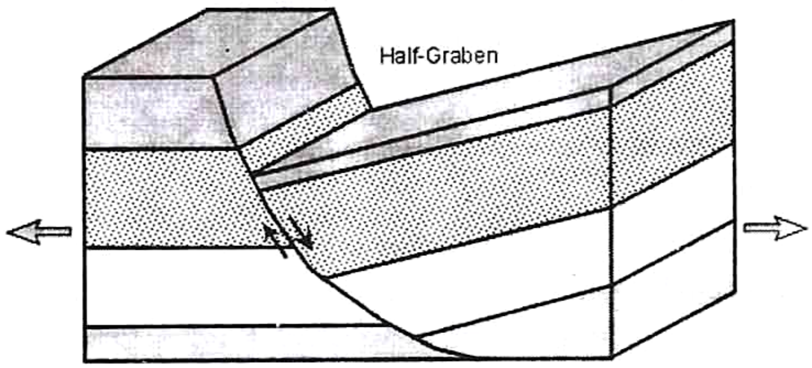
Due to the tensional stress responsible for normal faults, they often occur in a series, with adjacent faults dipping in opposite directions. In such a case the down-dropped blocks form grabens and the uplifted blocks form horsts. In areas where tensional stress has recently affected the crust, the grabens may form rift valleys and the uplifted horst blocks may form linear mountain ranges.

The East African Rift Valley is an example of an area where continental extension has created such a rift. The basin and range province of the western U.S. (Nevada, Utah, and Idaho) is also an area that has recently undergone crustal extension. In the basin and range, the basins are elongated grabens that now form valleys, and the ranges are uplifted horst blocks.



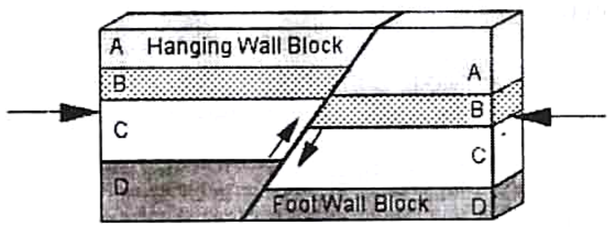
B) Half-Grabens

A normal fault that has a curved fault plane with the dip decreasing with depth can cause the down-dropped block to rotate. In such a case a half-graben is produced, called such because it is bounded by only one fault instead of the two that form a normal graben.



3 Reverse Faults

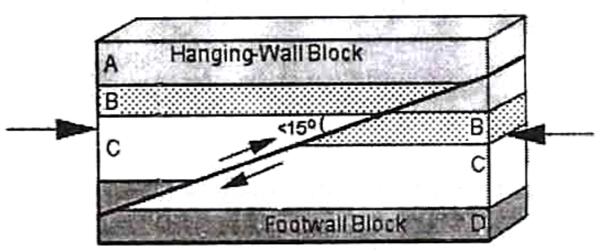
Are faults that result from horizontal compression stresses in brittle rocks, where the hanging-wall block has moved up relative the footwall block.



Reverse Fault
Compressional Stress

A) Thrust Fault

It is a special case of a reverse fault where the dip of the fault is less than 15o. Thrust faults can have considerable displacement, measuring hundreds of kilometers, and can result in older strata overlying younger strata.



Thrust Fault
Compressional Stress

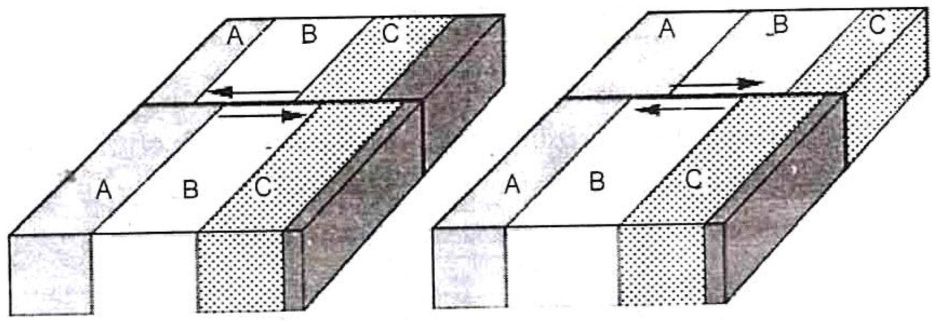
4 Strike Slip Faults

These are faults where the relative motion on the fault has taken place along a horizontal direction. Such faults result from shear stresses acting in the crust. Strike slip faults can be of two varieties, depending on the sense of displacement.

To an observer standing on one side of the fault and looking across the fault, if the block on the other side has moved to the left, we say that the fault is a left-lateral strike-slip fault.

If the block on the other side has moved to the right, we say that the fault is a right-lateral strike-slip fault.

The famous San Andreas Fault in California is an example of a right-lateral strike-slip fault. Displacements on the San Andreas fault are estimated at over 600 km.



left lateral strike slip fault   Right lateral strike slip fault

Shear Stress

5 Transform-Faults

These are a special class of strike-slip faults. These are plate boundaries along which two plates slide past one another in a horizontal manner. The most common type of transform faults occur where oceanic ridges are offset.

Note that the transform fault only occurs between the two segments of the ridge. Outside of this area there is no relative movement because blocks are moving in the same direction. These areas are called fracture zones. The San Andreas fault in California is also a transform fault.

5.Explain the various types of joint with neat sketch

Definition

Rocks subjected stress can be break without any displacement, such planar breaks are called as joints. Joints are almost in vertical pane. Fracture of regular origin/pattern can be said as joints.

There are several types of joints based on its formation and pattern.

1 Types with respect to formation

Tectonic joints

Tectonic joints are formed during deformation episodes whenever the differential stress is high enough to induce tensile failure of the rock, irrespective of the tectonic regime. They will often form at the same time as faults. Measurement of tectonic joint patterns can be useful in analyzing the tectonic history of an area because they give information on stress orientations at the time of formation.

Unloading joints (Release joints)

Joints are most commonly formed when uplift and erosion removes the overlying rocks thereby reducing the compressive load and allowing the rock to expand laterally. Joints related to uplift and erosional unloading have orientations reflecting the principal stresses during the uplift. Care needs to be taken when attempting to understand past tectonic stresses to discriminate, if possible, between tectonic and unloading joints.

Exfoliation joints are special cases of unloading joints formed at, and parallel to, the current land surface in rocks of high compressive strength.

Cooling joints

Joints can also form via cooling of hot rock masses, particularly lava, forming cooling joints, most commonly expressed as vertical columnar jointing. The joint systems associated with cooling typically are polygonal because the cooling introducing stresses that are isotropic in the plane of the layer.

2 Types with respect to attitude and geometry

Joints can be classified into three groups depending on their geometrical relationship with the country rock:

- **Strike joints** - Joints which run parallel to the direction of strike of country rocks are called "strike joints"
- **Dip joints** - Joints which run parallel to the direction of dip of country rocks are called "dip joints"
- **Oblique joints** - Joints which run oblique to the dip and strike directions of the country rocks are called "oblique joints".

3 Types with respect to the format

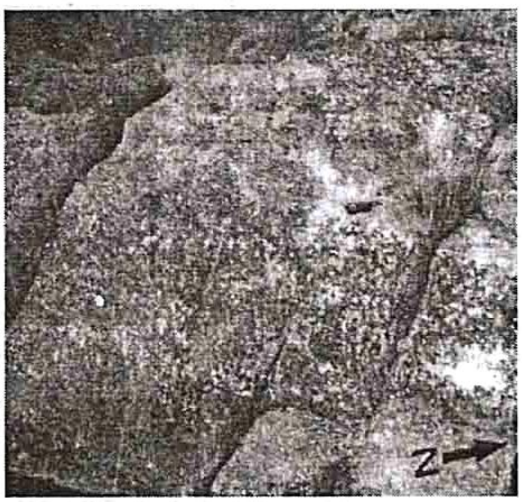
3.1 Systematic joints

Through planar geometry, regular parallel orientations, regular spacing.

3.2 Nonsystematic joints

Curved, irregular in geometry, always terminate against older joints which commonly belong to a systematic set

Cross joints - systematic joints of one set consistently terminate against the joints of another set



Cross joint

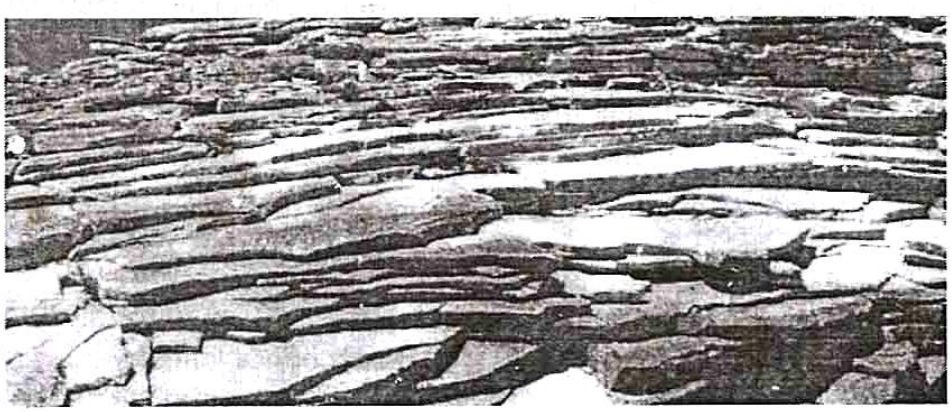
Diagonal joint

.3.3 Oblique / diagonal joints

Joints that cut a fold or some other linear feature at high angles.

.3.4 Sheet joints / Exfoliation joints

Curved extension fractures that are subparallel to the topography and result in a characteristic smooth, rounded topography, may be found in many kinds of rocks but they are best displayed in plutonic rocks in mountainous regions where the sheets resemble layers of an onion.



3.5 Columnar Joints

Extension fractures characteristic of shallow tabular igneous intrusions, dikes, sills, or thick extrusive flows; fractures separate the rock into roughly hexagonal or pentagonal columns which are often oriented perpendicular to the contact of the igneous body with the surrounding rock.

Columnar joint- pictural representation

6. Mapping and their applications and Symbols

GEOLOGICAL MAPS

- Geological maps are the basic criteria representing the structural features of the earth ant its orientation.
- It primarily focused with the data of the bedding planes such us fold, fault and joints.
- It provides information pictorially with colour variation and symbolic representations.
- A geological map is commonly used by the geologist for recording the information regarding the nature and topography of the earth such us outcrop, dip & strike.

1 Geological mapping

Remote sensing and geo informatics system plays a vital role in the geological mapping. Mapping is the graphical or pictorial representation of spatial and non-spatial data.

These data are predominantly collected by remote sensing and land topographical survey methods. Such a collected data are aligned by geo informatics system by means of GIS software.

After interpretation and analysis of data, it will be converted in to maps. It is done by plotting the location of certain selective stations and points.

Civil engineering requires certain site specific maps. General maps are prepared by geological survey of India or state mines and geological departments.

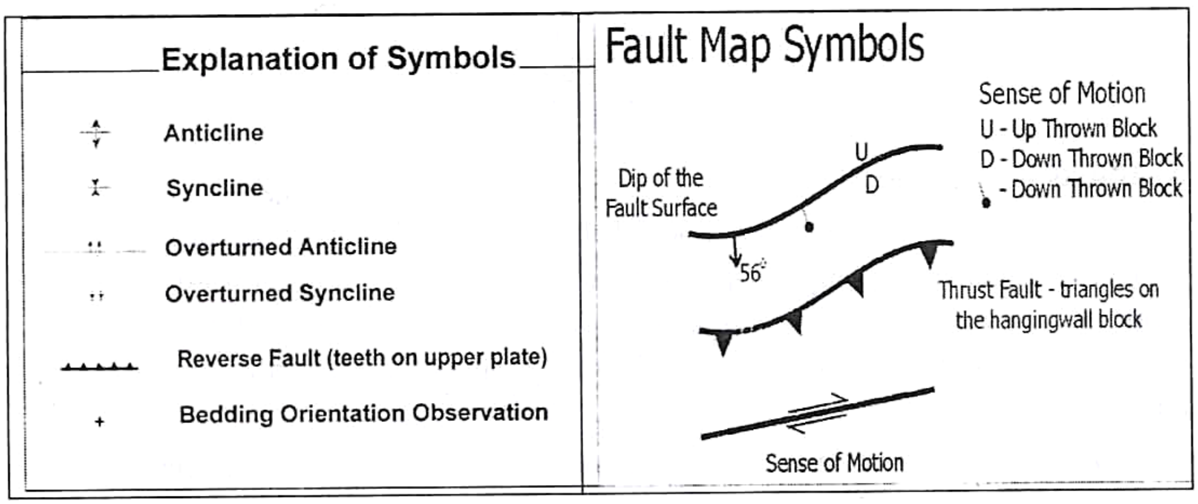
In all civil engineering projects the basic requirement is to prepare a site specific map with all geological features, rock types and their extensions. Such a map is prepared in field measuring the dimensions of the rock outcrops, hill features, and structural trends and is to be documented.

2 Application of geological maps

A geologic map is the principal tool that geologists use.

- To locate and differentiate the geologic hazards such as landslides and faults.
- To locate and differentiate the resources such as sand and gravel. coal, ore deposits, and ground water.
- To provide information for land use planning and growth.
- To provide visualized data that can't be access directly.
- To provide predictive and descriptive litho-logical information.
- To make easy understanding of alignment of earthen componenents.

3 Mapping symbols



7. Electrical resistivity method of geological investigation

- **Electrical resistivity methods**

These are also the indirect methods of soil exploration. The difference of electrical resistivity between the various strata is the base of this method.

Rocks or dense soil can be differentiated on the basis of electrical resistivity from the loose soil, as the value of electrical resistivity in rocks is higher than the value of electrical resistivity in loose soil.

It can also be observed as the difference in electrical resistivity above and below GWT. One of the effective methods is Wenner's four electrode method, ASTM G57.

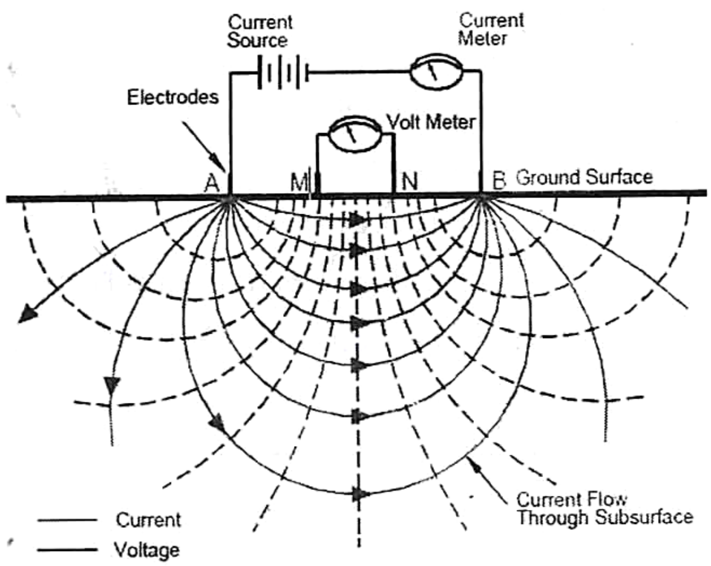
In this method of soil exploration generally two electrodes are buried into the ground and a potential is applied across these electrodes, the measurements are made on the basis of current flowing through the two electrodes or the potential drop across the intermediate electrodes.

The changes in the spacing between the inner electrodes depends upon the condition of the site and the requirement of the data (i.e. the intensity of investigation). The spacing between the electrodes should be constant.

resistivity method

Electrical resistivity method measures the earth resistivity by driving a direct current signal in to the earth and measures the resulting potentials created in the earth. From the data the electrical property of the earth can be derived from which the geo physical nature of earth can be resolved.

Diagram given below shows the schematic representation of basic principle of D.C. resistivity measurement. Two short metallic stakes are driven about 1 foot into the earth to apply the current to the ground. Two additional electrodes are used to measure the earth voltage (or electrical potential) generated by the current. Depth of investigation is a function of the electrode spacing. The grater the spacing between the outer current electrodes, the deeper the current will flow in the earth, hence the greater the depth of exploration. The depth of investigation is generally 20% to 40% of the outer electrode spacing, depending on the earth resistivity structure.



8.seismic method of geological investigation

These are the indirect methods of soil exploration.

- **Seismic methods**

In impact or explosion that generate sound waves are usually of three types, namely:

1. Surface waves (Rayleigh waves).
2. Compression waves.
3. Shear waves.

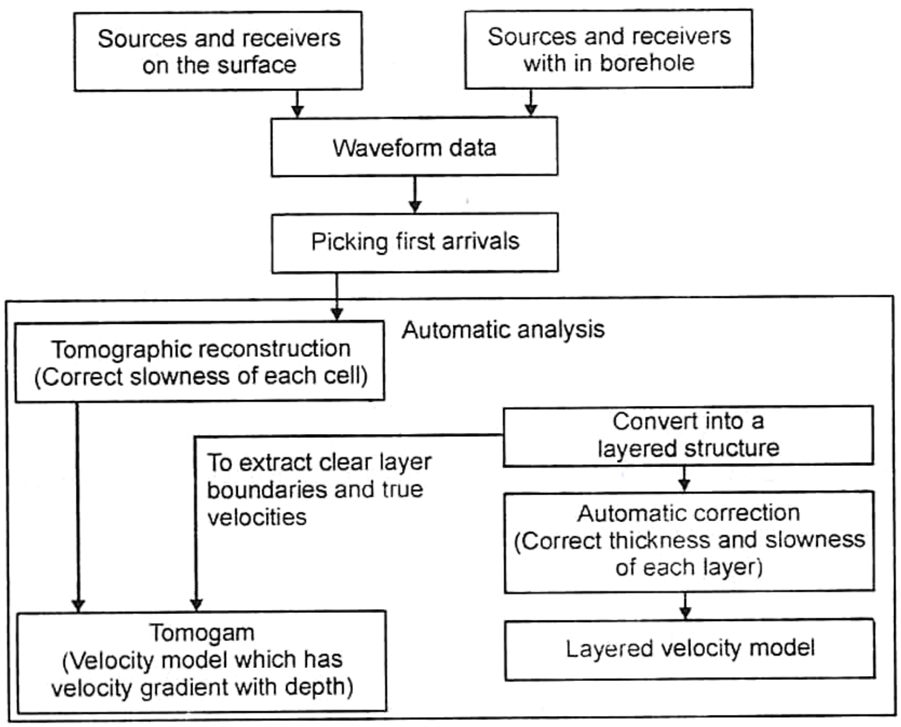
The second and third type of waves usually travel outward of the epicenter. The compression is arrived at any point first because it is fastest. The velocity with which the wave will pass through a medium depends upon the density of the material of the medium.

If the material is dense and rigid then the velocity of the traveling wave is higher, while if the medium is loose and flexible then the velocity of the wave traveling will be comparatively low.

Thus we can say that the change in velocity determines the boundaries of different materials. The method we use may be seismic refraction. It cannot be used when the velocity of traveling of lower stratum is less than that of upper material.

Seismic tomography

It is a technique used to find out the 3D image of the earth with the property study of compression (p-wave) and shear (s-wave) waves. Travel time measurements of these waves allow us to compile 3D images of earth's velocity structure.



2 Seismic refraction method

Seismic waves have different velocity in different regions or strata of the earth. Waves can be generated by means of explosions or striking a metal plate with hammer.

Two types of waves are produced.

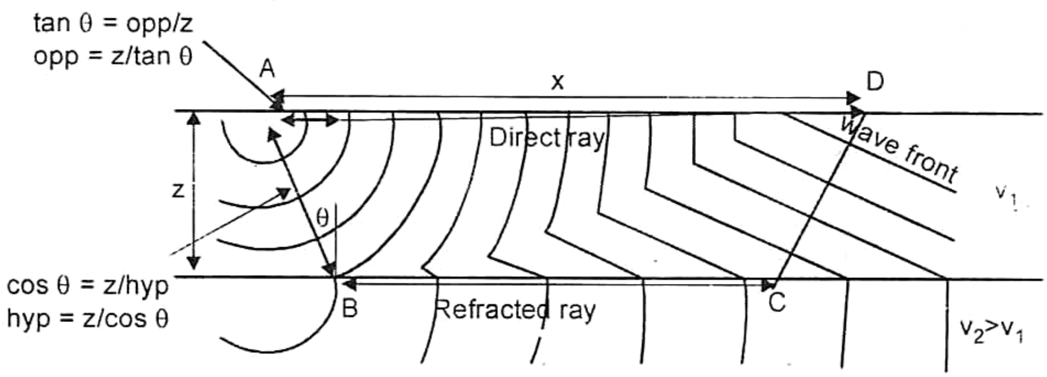
i) P-Waves (plane waves)

ii) S-Waves (shear waves)

Basic principle

- Longitudinal waves travel in a straight line in a medium of constant density.
- Waves are reflected when they come in to contact with soil strata of different density.
- Determine seismic velocity & compare with the known values.

Thus produced waves are refracted through the earth interior and are then received by the geophones which are fixed at the surface. Many such geophones are placed with specific interval. Distance of geophone is twice proportional to the distance of the depth of wave traveled.



Time traveled by the head waves is obtained by dividing the ray path segments by their respective velocity.

$t = t_{AB} + t_{BC} + t_{CD}$ Distance / Velocity = time (seconds)

$$= \frac{z}{v_1 \cos\theta} + \frac{(x - 2z\tan\theta)}{v_2} + \frac{z}{v_1 \cos\theta}$$

Travel time equation can be reformulated in to a more useful form using $\sin\theta = V_1/V_2$

$\tan\theta = \sin\theta / \cos\theta$

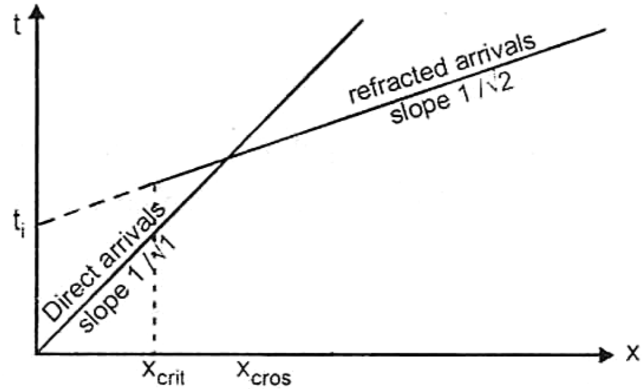
$\cos^2\theta = 1 - \sin^2\theta$

$\cos\theta = (V_1^2/V_2^2)^2$

$$t = \frac{z}{v_1 \cos\theta} + \frac{(x - 2z\tan\theta)}{v_2} + \frac{z}{v_1 \cos\theta}$$

$$t = \frac{x}{v_2} + \frac{2z(v_2^2 - v_1^2)^{1/2}}{v_1 v_2} \nwarrow \text{intercept } t$$

The intercept term is rearranged and solved for depth



$$t_i = \frac{2\tau\,(v_2^2 - v_1^2)^{1/2}}{v_1 v_2}$$

$$z = \frac{t_i\, v_1 v_2}{2(v_2^2 - v_1^2)^{1/2}}$$

Thus based on the comparative analysis of the obtained data and the standard data which available on specified codes the type, texture, structure and grades of the soil can be found.

9. bearing on engineering construction

BEARING ON ENGINEERING CONSTRUCTION

Bearing capacity failures of structures founded on rock masses are dependent upon joint spacing with respect to foundation width, joint orientation, joint condition (open or closed), and rock type.

Prototype failure modes may actually consist of a combination of modes. For convenience of discussion, failure modes will be described according to four general rock mass conditions: intact, jointed, layered, and fractured.

1 Intact Rock Mass

For the purpose of bearing capacity failures, intact rock refers to a rock mass with typical discontinuity spacing greater than four to five times the width of the foundation.

As a rule, joints are so widely spaced that joint orientation and condition are of little importance. Two types of failure modes are possible depending on rock type.

The two modes are local shear failure and general wedge failure associated with brittle and ductile rock, respectively.

a. Brittle rock. (Fault appearance)

A typical local shear failure is initiated at the edge of the foundation as localized crushing (particularly at edges of rigid foundations) and develops into patterns of wedges and slip surfaces.

The slip surfaces do not reach the ground surface, however, ending somewhere in the rock mass. Localized shear failures are generally associated with brittle rock that exhibit significant post-peak strength loss.

b. Ductile rock (Fold appearance)

General shear failures are also initiated at the foundation edge, but the slip surfaces develop into well defined wedges which extend to the ground surface.

General shear failures are typically associated with ductile rocks which demonstrate post-peak strength yield.

2 Jointed Rock Mass

Bearing capacity failures in jointed rock masses are dependent on discontinuity spacing, orientation, and condition.

a. Steeply dipping and closely spaced joints

Two types of bearing capacity failure modes are possible for structures founded on rock masses in which the predominant discontinuities are steeply dipping and closely spaced. Discontinuities that are open offer little lateral restraint.

Hence, failure is initiated by the compressive failure of individual rock columns. Tightly closed discontinuities on the other hand, provide lateral restraint. In such cases, general shear is the likely mode of failure.

b. Steeply dipping and widely spaced joints

Bearing capacity failures for rock masses with steeply dipping joints and with joint spacing greater than the width of the foundations are likely to be initiated by splitting that eventually progresses to the general shear mode.

c. Dipping joints

The failure mode for a rock mass with joints dipping between 20 to 70 degrees with respect to the foundation plane is likely to be general shear.

Bearing equations for various failure modes

S.No	Mode of rocks	Bearing equation
1	Brittle rock – Local Shear failure	$q_{ult} = 0.5 \; BN. \; cN_c$
2	Ductile rock – general shear failure	$q_{ult} = cN_c + 0.5 \; BN. \; DN_q$
3	Open joint – compressive failure	$q_{qult} = t\,2\,c\tan(45 + /2)$
4	Closed joint – General shear failure	$q_{ult} = cN_c + 0.5 \; BN. \; DN_q$
5	Open or Closed joints – Failure	$q_{ult} = JcN_{cr}$
6	Moderately dipping joint - General failure	$q_{ult} = 0.5 \; BN. \; DN_q$
7	Thin rigid upper layer – failure is initiated by tensile failure	N/A
8	Thin rigid upper layer – failure is initiate by the punching tensile failure	N/A
9	General shear failure with irregular failure surface through rock mass	$q_{ult} = 0.5 \; BN. \; DN_q$

qult = The ultimate bearing capacity

? = Effective unit weight (i.e. submerged unit wt. if below water table) of the rock mass

B = Width of foundation

D = Depth of foundation below ground surface

C = The cohesion intercepts for the rock mass

The term Nc, Nq, N?, are bearing capacity factors.

10) Write short notes on

a) **Outcrop**
b) **Bedding**
c) **Dip and Strike**

Outcrop:

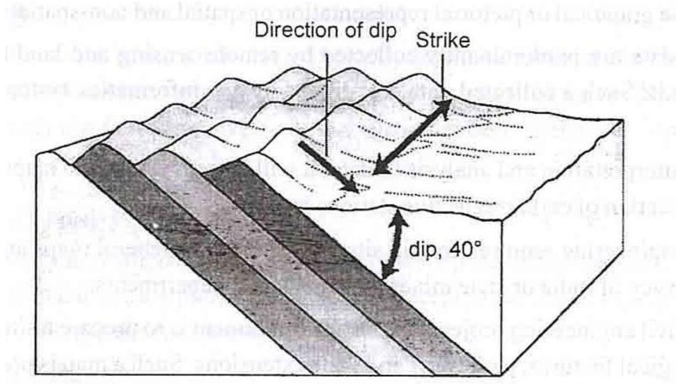
Solid rock is not exposed everywhere on the surface; it is often covered by thin or thick layer of alluvium or soil. In certain regions alluvium or soil may be spread for thousands of square kilometers and the bed rock may not be visible anywhere. In other area however exposures of rocks may be easily seen forming sides of valleys or caps of the hills or even flatlands in fields. An outcrop is the exposures of a solid rock on the surface of the earth.

Bedding:

Most sedimentary rocks are deposited under conditions which favor development of distinct layers from bottom to top. These layers are often easily distinguished on the basis of variation in color composition and grain size. It is sedimentary rocks are the most widespread on the surface of the earth. Forming more than 75 percent of all the rocks exposed. This layered character called Stratification or bedding therefore of fundamental significance in the study of structural features of sedimentary rocks

Dip and Strike:

These are two definite quantities by which the position or attitude of a body of rock, especially stratified is expressed.



DIP:

It is defined as the maximum angle of slope of a bed or layer of rock with the horizontal. It is expressed both in terms of degree of inclination and direction of inclination.

The amount of dip is the angle between the bedding plane and a horizontal plane.

STRIKE:

It is a geographic direction of extension of the layers of rocks and may be explained as the direction of intersection of the bedding plane with a horizontal plane

Apparent and True Dip:

The direction in which dip is measured in the field may have any relation with the strike of the bed.

True dip is the dip angle of a layer which is measured in a direction exactly at right angles to the strike of that layer.

The dip angle measured at any other direction with the strike of a layer is termed as apparent dip. The true dip and apparent dip values are related to each other in the following manner:

Where α is the apparent dip angle. B is angle of true dip and γ is the angle between the strike of the layer and the direction in which apparent dip is being measured.

Types of Dip:

Besides true dip and apparent dip is also differentiated in the following ways:

Primary Dip:

It is the inclination of strata or layers due to original slope of the basin of deposition. If the original surface of the basin where sedimentary rocks are deposited is slopping. Primary dips generally low, invariably less than 35^0 and commonly between $0\text{-}20^0$. These inclinations are also termed as depositional gradient.

Secondary dip:

It is the inclination induced in the strata subsequent to its deposition under the influence of forces to which such strata might have been subjected. It may range to any value upto the vertical.

Local Dip:

These are inclinations of the rocks exposed on a particular area of examination. These may be primary or secondary in character and may or may not show any variation with depth or laterally.

Regional dip:

By regional dip is understood a general inclination of series of rock layers exposed over wide area. These rocks may show varying local dips but when considered as a whole.

UNIT V –Dimensional Analysis and Model studies

Fundamental Dimensions – Dimensional Homogeneity – Rayleigh's method and Buckingham Pi Theorem – Dimensionless parameters – Similitude and model studies – Distorted models.

Dimensional Analysis:

Dimensional analysis is a mathematical technique which makes use of the study of dimensions as an aid to the solution of several engineering problems.some of the uses of dimensional analysis are narrated as follows:

- Testing the dimensional homogeneity of any equation of fluid motion
- Deriving equations expressed in terms of non-dimensional parameters to show the relative significance of each parameter
- Planning model tests and presenting experimental results in systematic manner in terms of non-dimensional parameters; thus making it possible to analyze the complex fluid flow phenomenon

Dimensions:

The primary quantities are mass, length, time and temperature, designated by the letters M, L, T and θ respectively. The expression for a derived quantity in terms of the primary quantities is called dimension of the Physical Quantity.

Some of the dimensions are given in the below table:

Quantities	Units of measurement	Dimensions
Length	m	L
Volume	m^3	L^3
Slope	m/m	$M^0 L^0 T^0$
Velocity	m/s	$L T^{-1}$
Discharge	m^3/s	$L^3 T^{-1}$
Mass	kg	M
Force	N (kgm/s^2)	$M^1 L^1 T^{-2}$

Dimensional Homogeneity:

Fourier's Principle of dimensional homogeneity states that an equation which expresses a physical phenomenon of fluid flow must be algebraically correct and dimensionally homogeneous.

An equation is said to be dimensionally homogeneous, if the dimensions of the terms on its left hand side are same as the dimensions in the right hand side.

To illustrate,

Consider, the equation of discharge over a rectangular weir,

$$Q = \frac{2}{3}\, c_d \sqrt{2g}\; L\, H^{3/2}$$

$$L^3\, T^{-1} = L^{1/2}\, T^{-1}\, L\, L^{3/2}$$

$$L^3\, T^{-1} = L^3\, T^{-1}$$

<u>Methods of Dimensional Analysis:</u>

The following are the methods of dimensional analysis generally used:

1. Rayleigh's method
2. Buckingham π method

<u>Rayleigh Method:</u>

In this method a functional relationship of some variables is expressed in the form of an exponential equation which must be dimensionally homogeneous

Thus if X is some function of variables X_1 , X_2 ,$X_{3,}$ X_4…… X_n ; the functional equation may be written in the general form

$X = fn(X_1 , X_2 ,X_{3,} X_4 \ldots\ldots X_n)$

In this equation X is a dependent variable , X_1 , X_2 ,$X_{3,}$ X_4…… X_n are independent variable.

The above equation may be expressed as

$X = C\, (X_1{}^a X_2{}^b X_3{}^c X_4{}^d \ldots\ldots X_n{}^n)$

The exponents a, b, c, d..... n are then evaluated on the basis that the equation is dimensionally homogeneous.

The dimensionless parameters are then formed by grouping the variables with like powers.

<u>Buckingham π Method:</u>

The Buckingham π theorem states that if there are n dimensional variables involved in a problem, which can be completely described by m fundamental quantities or dimensions (such as mass, length, time etc.,) and are related by a dimensionally homogeneous equation, then the relationship among the n quantities can always be expressed in terms of exactly (n-m) dimensionless and independent π terms.

Thus if X is some function of variables X_1, X_2, X_3, X_4…… X_n ; the functional equation may be written in the general form

$X = fn(X_1, X_2, X_3, X_4 \ldots\ldots X_n)$

No. of variables involved in the problem i.e., n = ?

No. of Primary quantities , m =?

No. of dimensionless parameters π = n- m

No. of repeating variables = m

To form the dimensionless equation,

- In each equation, there are m number of repeating variables
- If there are three repeating variables ,it is chosen such that,
    - The first repeating variable is a geometric quantity
    - The second on is kinematic quantity
    - The third one is dynamic quantity
- The dependent variable is not chosen as repeating variable
- After the dimensionless parameters are formed, the powers are evaluated for the dimensions
- The final general equation for the phenomenon may then be obtained by expressing any one of the π terms as the function of others.

Dimensionless Parameters:

- Inertia to Viscous force ratio – Reynolds's Number
- Inertia- Gravity force ratio – Froude number
- Inertia to pressure Force ratio – Euler number
- Inertia to Elasticity Force ratio – Mach number
- Inertia to surface Force – Weber number

Similitude – Types of Similarities:

There are in general three types of similarities to be established for complete similarity to exist between the model and its prototype. These are

a. Geometric Similarity
b. Kinematic similarity
c. Dynamic similarity

Types of Model:

In general hydraulic models can be classified under two broad categories

i. Distorted Models
ii. Undistorted Models

Distorted Models:

- Distorted Models are those in which one or more terms of the model are not identical with their counterparts in the prototype
- Results are liable to distortion
- Have more qualitative value only
- The distortion may be geometrical distortion, material distortion, or distortion of hydraulic quantities
- The following are some of the reasons for adopting distorted models
    - to maintain accuracy in vertical measurements
    - To maintain turbulent flow
    - To obtain suitable bed material and its adequate movement
    - To obtain suitable roughness condition
    - To accommodate the available facilities such as space, money, waste supply and time.

Undistorted Models:

- Undistorted model is that which is geometrically similar to its prototype
- Perfect similitude is satisfied
- Prediction in the case of such model is relatively easy