ENGINEERING MATERIALS: BASED ON CHEMICAL & ATOMIC STRUCTURE

Type	Characteristics	Examples	Uses/application
Metals & alloys	Lustre, strength, hardness, ductility, malleability, stiffness, thermal and electrical conductivity, magnetism, machinability, formability, corrosion resistance, opaque	Metals: Iron, copper, aluminium, zinc, magnesium, titanium. Alloys: steel, cast iron, brass, bronze, duralumin	Structural materials, machinery, heavy equipment, household appliances, cable , wires, rope
Ceramics	High hardness, brittleness, thermal resistance, high temperature strength, abrasiveness, resistance to corrosion, electrical insulators,	Sand, Brick, Silicon carbide, tungsten carbide, boron nitride, clay, minerals, refractory bricks	Building materials, cutting tools, furnace lining, porcelain ware, electrical and thermal insulators, grinding and polishing wheels
Polymers	Soft, light weight, poor conductor of heat & electricity.	Rubber, leather, cotton, jute, resins, starch, synthetic fibre like nylon, terylene, plastics like PVC, PTPE, polyethylene	House hold appliances, textiles, insulators, lubricants, detergents, explosives, adhesives, coating material, decorating materials
Composite	Combination of best chara of components (strength &	Fibre glass & reinforced plastics,	Structural materials, cutting tools, bearing

ENGINEERING MATERIALS: PROPERTIES

Strength: Tensile , compressive, shear, endurance….. ***Ability to withstand the load without failure.***

Toughness: ***Ability of material to absorb energy without rupture***

Hardness: ***Ability of material to withstand scratching and indentations***

Malleability: ***Ability of material to be drawn in to thin sheets under compressive forces.***

Ductility: ***Ability of material to be drawn in to thin strands or fibres under tensile force.***

Electrical and thermal conductivity: ***ability of material to allow heat/current to flow through it.***

Thermal resistance: ***ability of material to withstand temperature***

ENGINEERING MATERIALS: PROPERTIES

Brittleness: ***Material when subjected to stress will rupture without any deformations***

Abrasiveness: ***Material wearing of due to friction of rubbing against other surfaces***

Corrosive: ***Slow destruction of materials due to chemical actions***

Machinability: ***Ease with which a material can be cut/ removed to get desired shape and finish.***

Formability: ***The ability of a material to undergo plastic deformation with out failure to get desired shape.***

Stiffness: ***The rigidity of material, ability to resist plastic deformation***

ENGINEERING MATERIALS: ATOM ARRANGEMENT

Crystalline materials : ***Atoms are arranged in regular, repetitive manner having long range order.***
**** When the arrangement of atoms is perfect we get single crystal.***
**** Only available naturally, difficult to make on our own***

Amorphous Materials: ***Atoms doesn’t have regular arrangement , order or form.***
**** Also called non crystalline materials***

Molecular materials: ***grouping of atoms occurs in short range, these groups are called molecules.***

Engineering Materials: Some Modern Materials

Semiconductors: ***Materials having electrical properties which are between conductors and insulators***

Biomaterials: ***Used for components implanted in human body as replacement for body parts***

Smart materials: ***Materials which can adapt and respond to various changes in operating environments.***

Nano materials: ***New materials being build from atomic levels (nano scale level)***

CRYSTALLOGRAPHY

Branch of science which deals with structure and properties of crystals

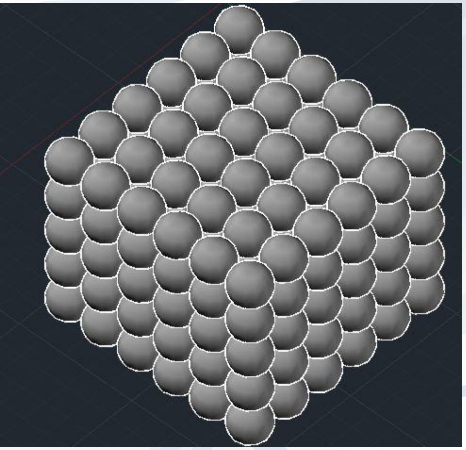
A crystal is a 3-D periodic arrangement of atoms in space

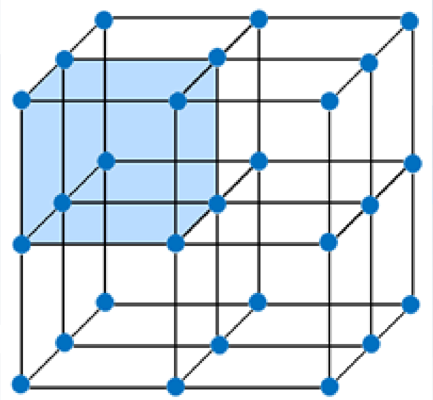
" A material in which atoms are situated in a repeating or periodic array over large atomic distances such that upon solidification, atoms will position themselves in a repetitive three dimensional pattern in which each atom is bonded to its nearest neighbour atoms"

****All metallic materials, many ceramics and certain polymers form crystalline structure under normal solidification***

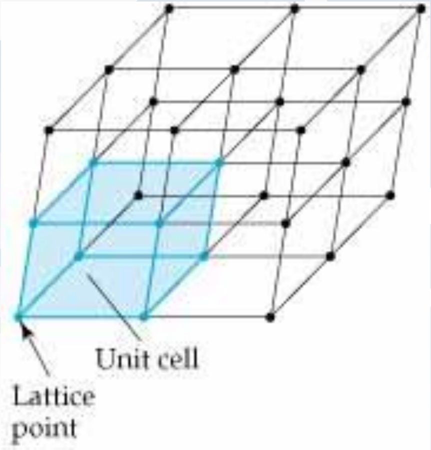
SPACE LATTICE/ CRYSTAL LATTICE

It is the three dimensional network of lines whose intersections generate three dimensional network of points which are occupied by atoms or about which group of atoms are clustered forming the crystalline material.





A Portion of three dimentional cubic lattice and its unit cell



The points on the space lattice are known as lattice points

Basis/Motif: Group of one or more atoms which are associated with each lattice point

UNIT CELL

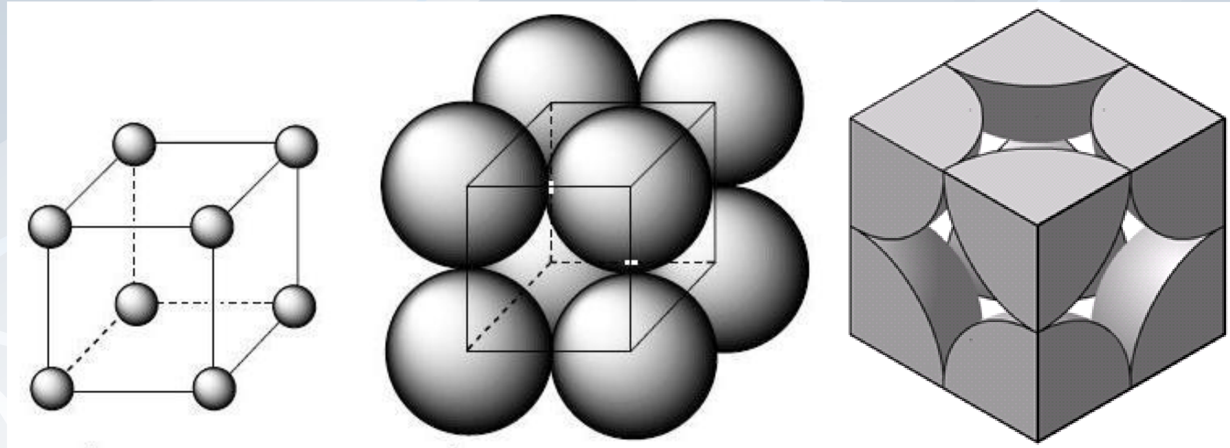
A fundamental group of atoms which when repeated will produce the crystal

- ***Basic building block of crystal***
- ***Unit cell is smallest unit which when repeated in space indefinitely will generate the space lattice.***
- ***Defines the symmetry and structure of entire crystal.***
- ***A unit cell is chosen to represent the symmetry of crystal structure.***
- ***Lattice parameters/Lattice vectors /Lattice constants:***

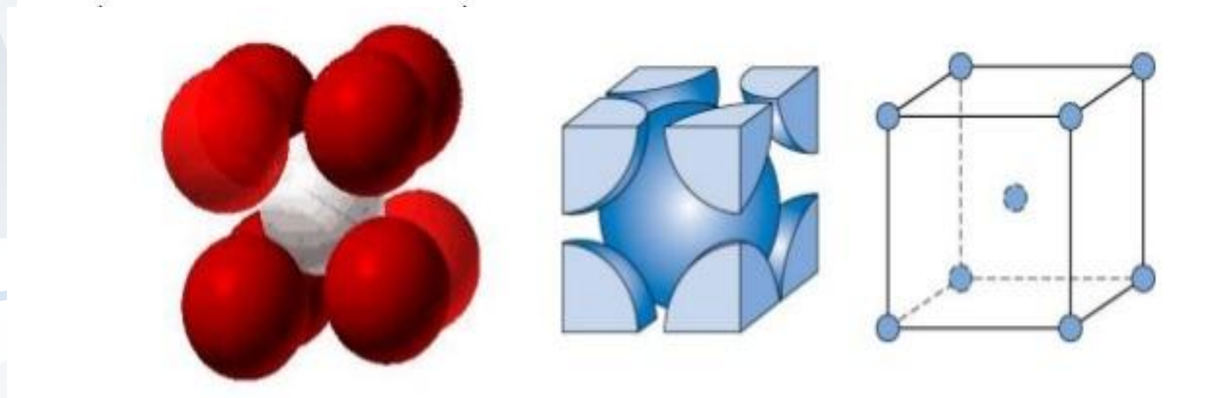
The inter atomic spacing (a, b, c) along the three axes and the inter axial angles (α, β, ϒ)

BASIC ARRANGEMENTS OF ATOMS WITHIN UNIT CELL

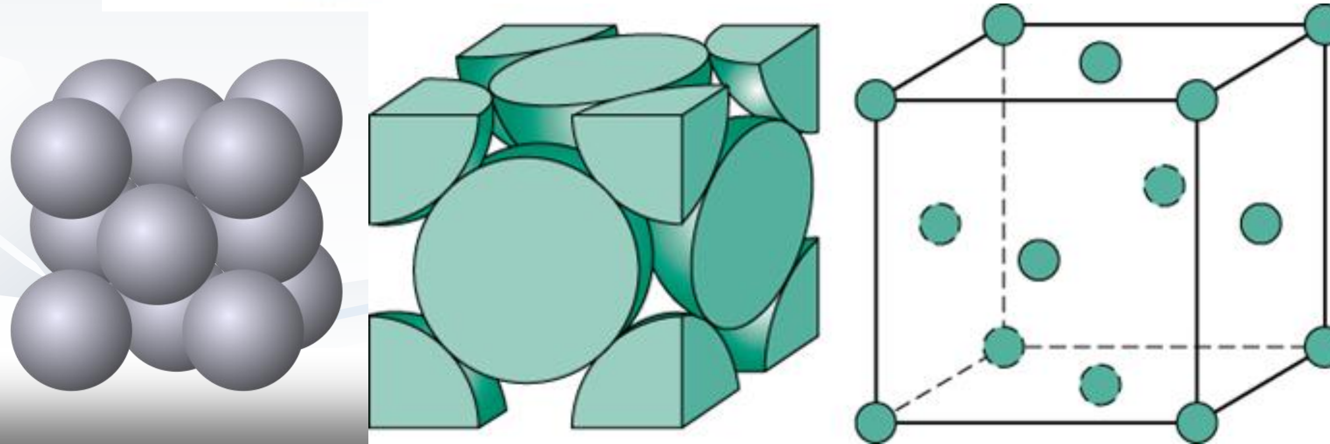
SIMPLE CUBIC



BODY CENTRED CUBIC

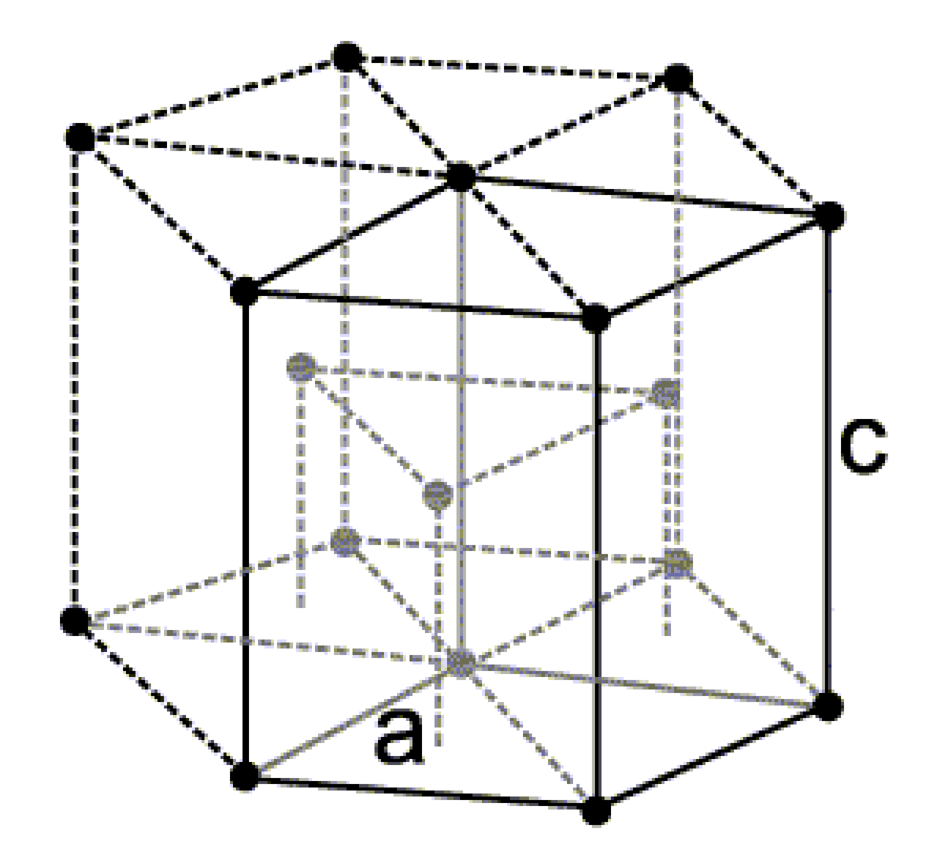


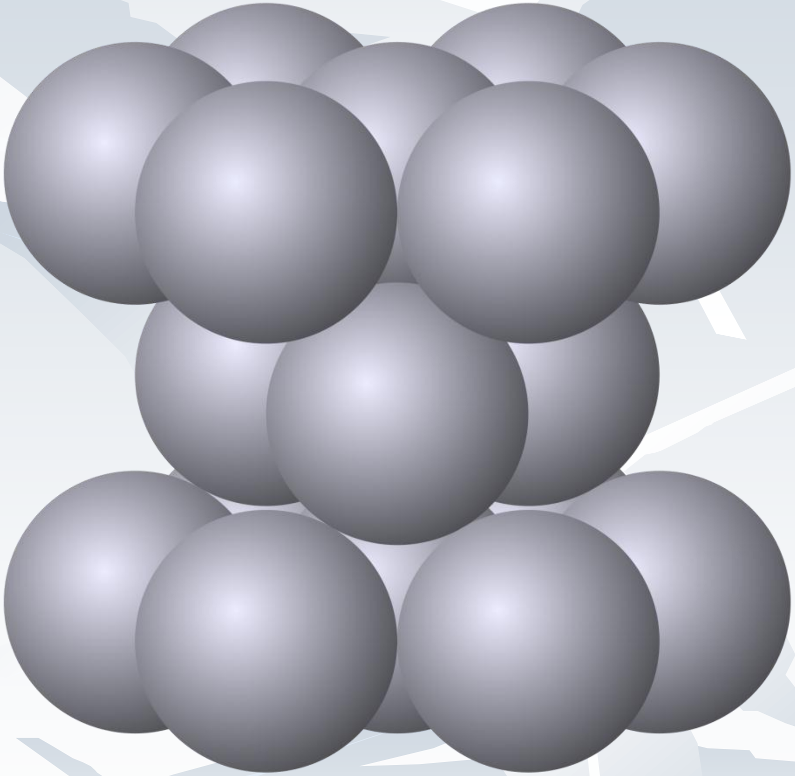
FACE CENTRED CUBIC



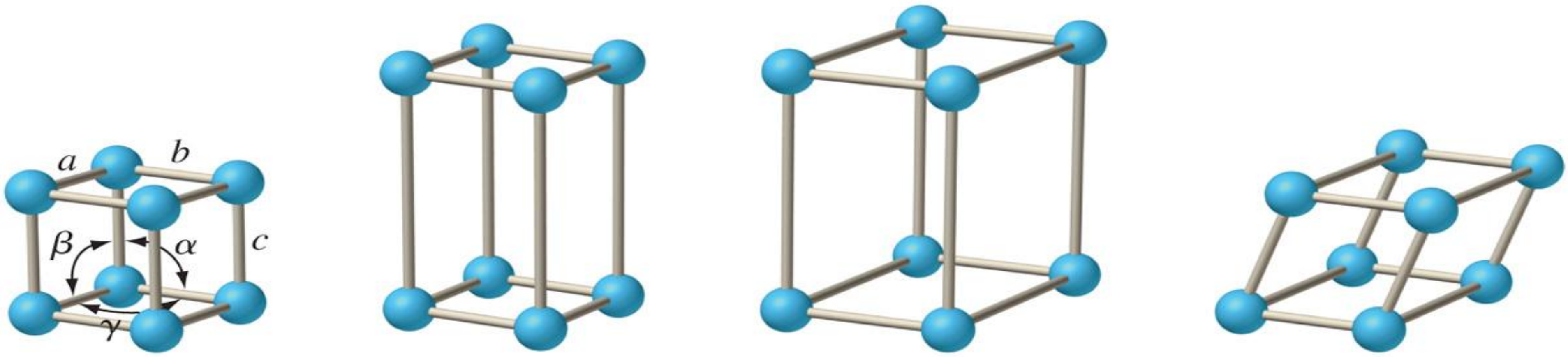
HEXAGONAL CLOSE PACKING

How atoms are there in this unit cell ?





CRYSTAL SYSTEMS AND THE UNIT CELL

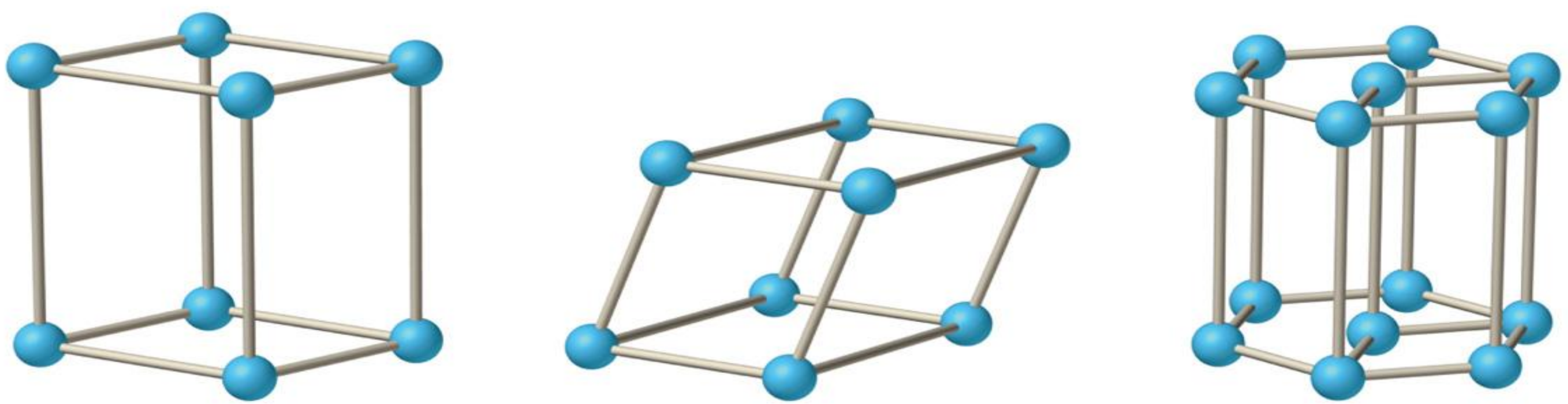


Simple cubic
$a = b = c$
$\alpha = \beta = \gamma = 90^\circ$

Tetragonal
$a = b \neq c$
$\alpha = \beta = \gamma = 90^\circ$

Orthorhombic
$a \neq b \neq c$
$\alpha = \beta = \gamma = 90^\circ$

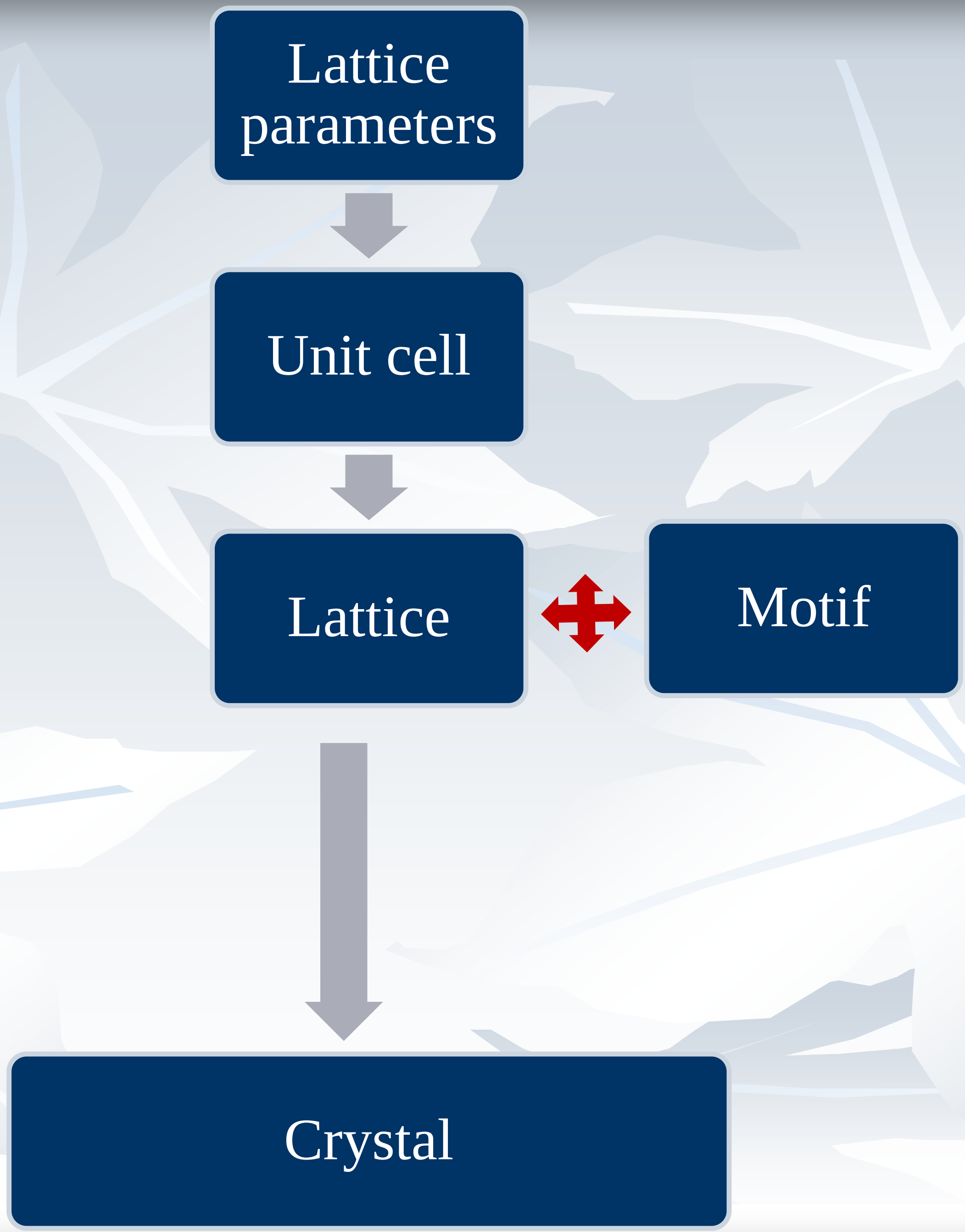
Rhombohedral
$a = b = c$
$\alpha = \beta = \gamma \neq 90^\circ$



Monoclinic
$a \neq b \neq c$
$\gamma \neq \alpha = \beta = 90^\circ$

Triclinic
$a \neq b \neq c$
$\alpha \neq \beta \neq \gamma \neq 90^\circ$

Hexagonal
$a = b \neq c$
$\alpha = \beta = 90^\circ, \gamma = 120^\circ$


Lattice parameters
Unit cell
Lattice
Motif
Crystal

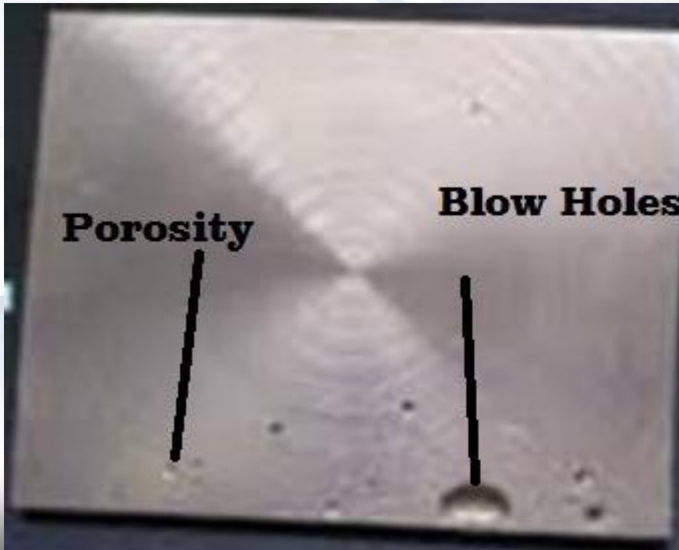
TESTING OF ENGINEERING MATERIALS

To check whether material selected has the required properties to ensure safe design.

***Visual inspection:* surface cracks, hot tears, blow holes, porosities, misrun, mismatch through naked eye or magnifying glass.**

**** Should be held at 24 inches from eye and surface should be minimum 30 degree inclined.***

**** If this is not satisfied mirrors magnifying lens, microscopes can be used***



Geometric checking for shapes and dimensions:

Use of proper gauges and measuring instruments to check dimensional accuracy.

Pressure testing : ***to ensure the part can withstand the design pressure***

Leak Testing: ***to ensure that the part is leak proof***

Testing for mechanical properties (Destructive testing)

**** Tensile and bending test using Universal Testing Machine (UTM)***
**** Impact test to check toughness using Izod and Charpy test***
**** Brinell & Rockwell test to check hardness of the specimen***
**** Etch test to check soundness of weld***

Testing to detect internal defects (Non Destructive Testing)

**** X-ray Radiography***
**** Gamma Ray Radiography***
**** Ultrasonic Testing***
**** Fluorescent penetrant inspection***

X RAY & GAMMA RAY RADIOGRAPHY

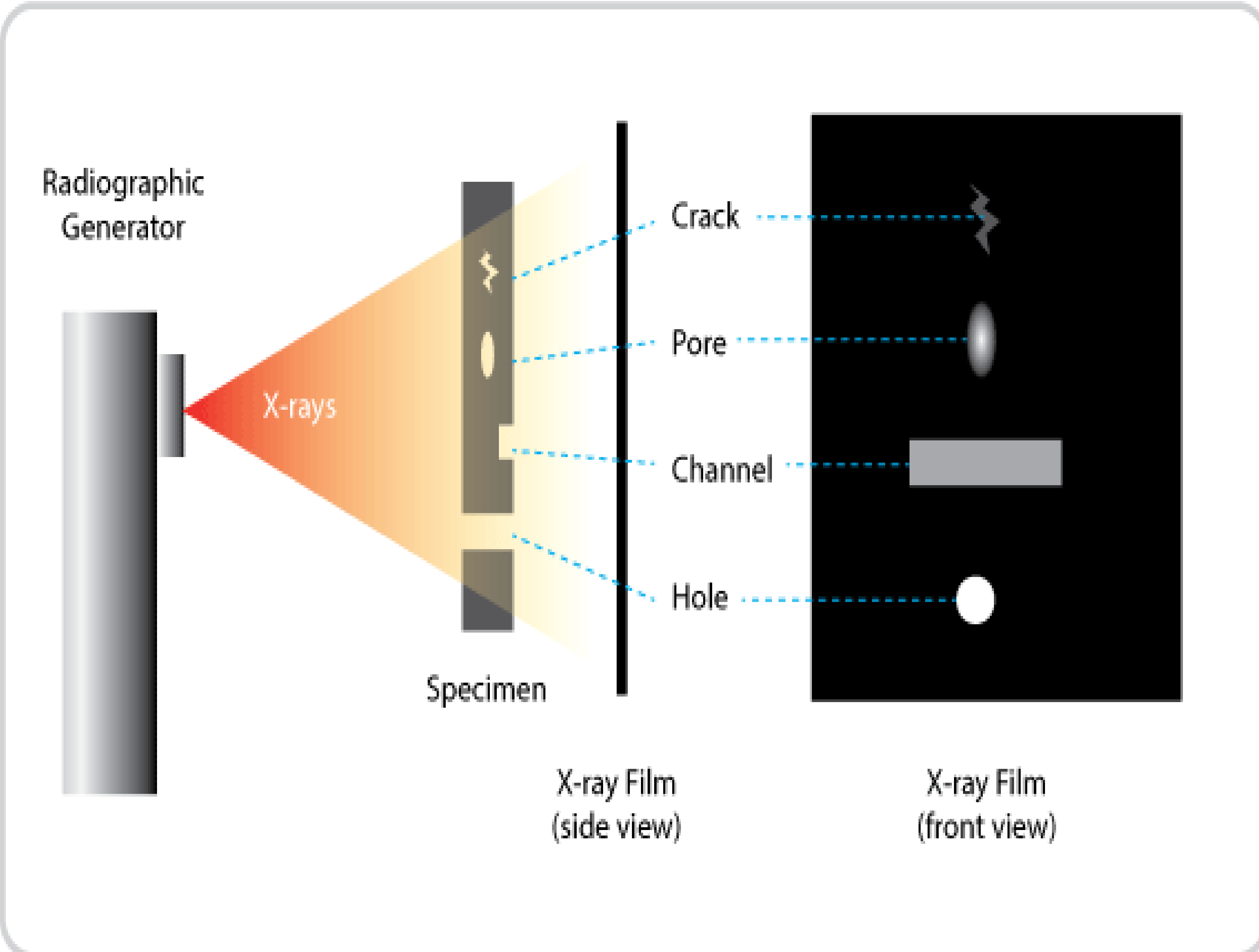
The part to be tested is placed between the radiation source and a radiation sensitive film

When exposed, radiation passes through the part and falls on to the film forming a shadowgraph.

The film darkness varies with amount of radiation reaching the film through the test object.

Darker regions indicate that greater exposure and lighter regions indicate less exposure.

This variation in image darkness can be used to study: thickness, material composition, flaws or discontinuities.



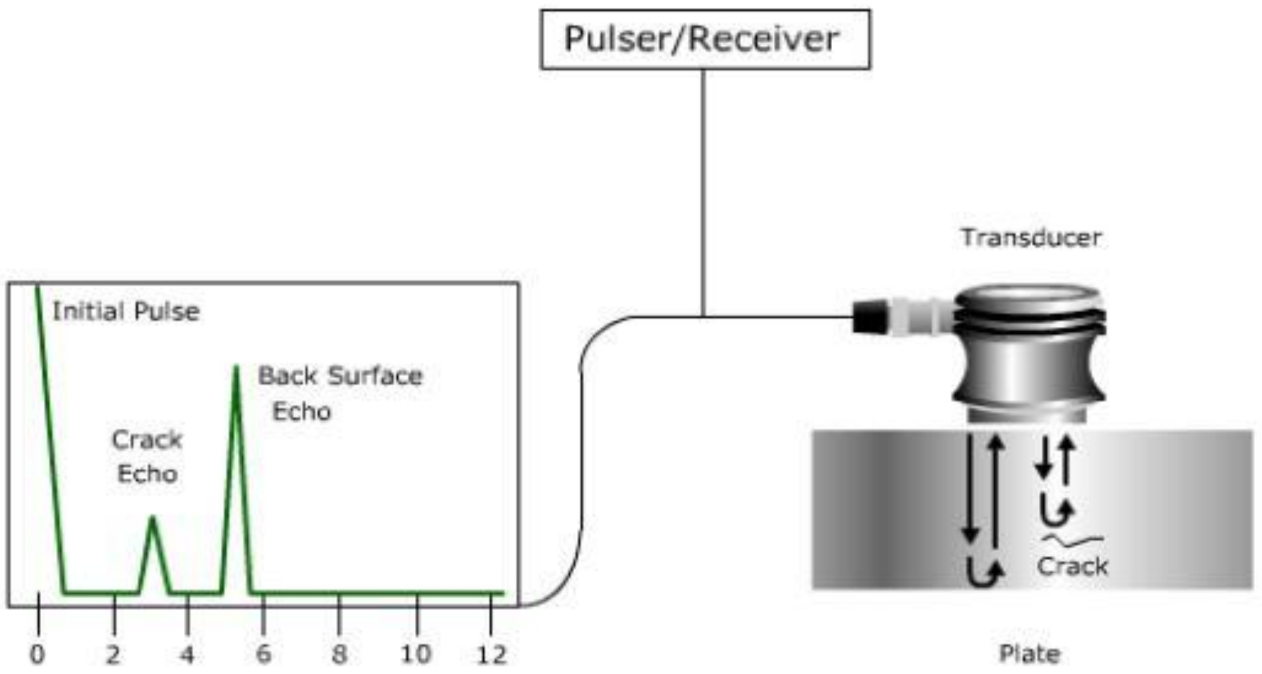
Radiographic Generator
X-rays
Specimen
Crack
Pore
Channel
Hole
X-ray Film (side view)
X-ray Film (front view)

UULTRASONIC TESTING

Uses high frequency sound waves.

Flaw detection, Defect evaluation, Dimensional measurement Material Characterization

Pulser generates high voltage electric pulse corresponding to the reflected waves



FLUORESCENT PENETRANT TESTING

Oldest method of non destructive testing (19th century, used kerosene)

Reveals surface discontinuities by bleedout of colored / fluorescent dye

- ***The dye is applied on to the CLEAN surface to be inspected.***
- ***If present, the dye flows into the cracks due to capillary action.***
- ***After a period of time called "Dwell time" excess dye is removed.***
- ***Developer is applied over the surface.***
- ***Developer acts a blotting paper (blotter) and draws the dye from the discontinuities to reveal its presence.***