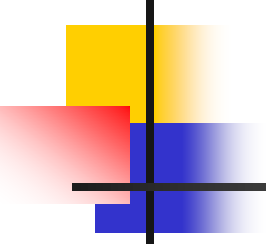
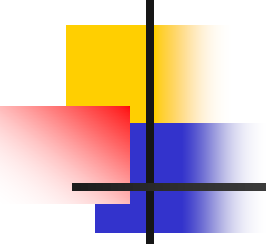


WORKSHOP PRACTICES



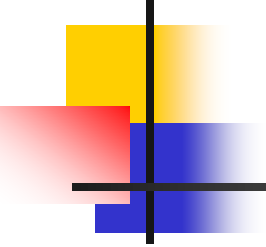
BASIC STEPS

1. Design concepts
2. Selection of materials
3. Manufacturing



DESIGN REQUIREMENTS

- Objectives to achieve Geometry, Size and finish
- Prepare for manufacturing Drawing + Material

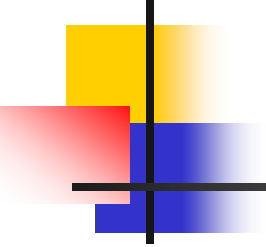


DRAWING

- Communication of information

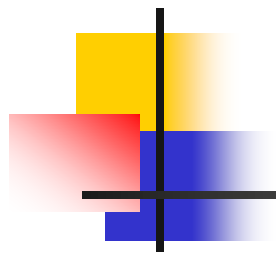
Shape, size, and features

- Universal language of engineering
- Graphical construction



DRAWING SKILLS

- **Drawing:** Interpretation and creation
- **Dimensioning:** Proper communication
- **Tolerances:** Manufacturer's limits

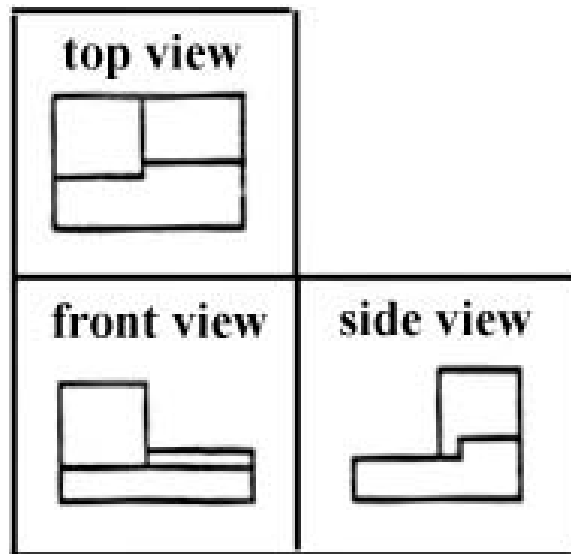


BASIC INFORMATION

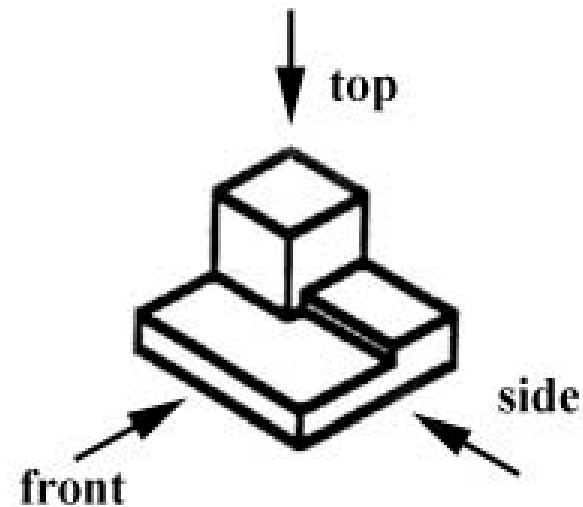
- **Projected Views:** Show as many views showing completeness.
(Front, Side, Top, others.)
- **Cross Sections:** A view that is good for showing interior features.
- **DIMENSIONS:** Most important

PROJECTIONS

(Orthographic representation)

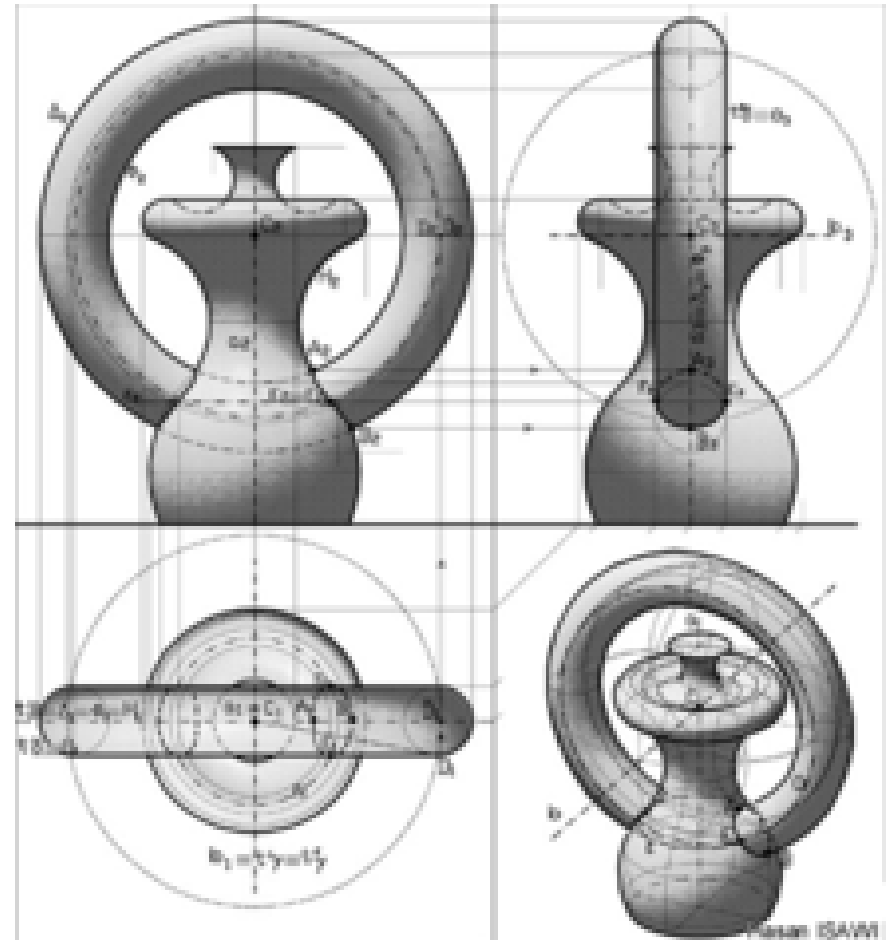


Front, Top, Side Views.



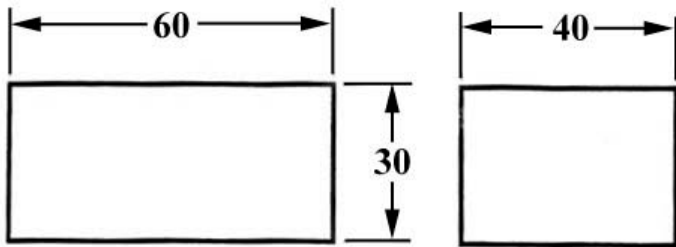
Isometric .

Two-dimensional representation of three- dimensional objects

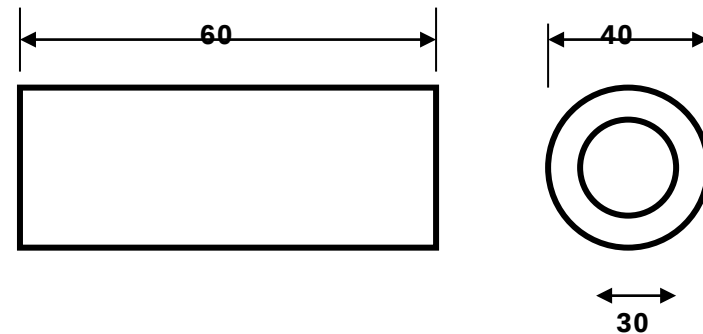


DIMENSIONS

- To build the structure or fabricate parts



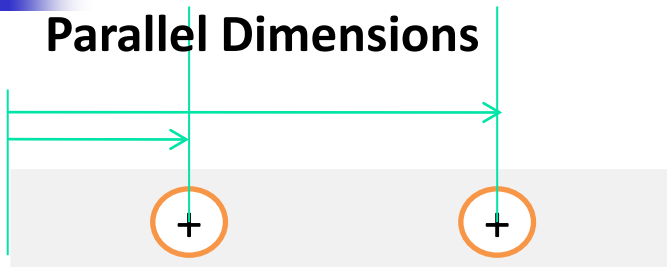
Simple Object 1



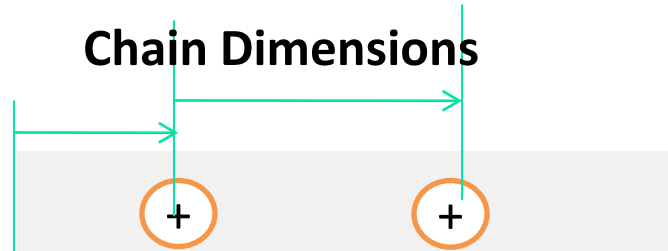
Simple Object 2

DEFINING DIMENSIONS

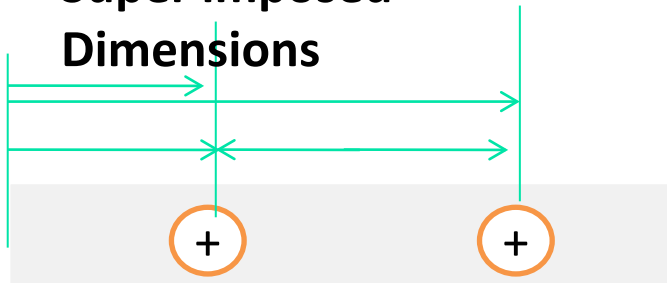
Parallel Dimensions



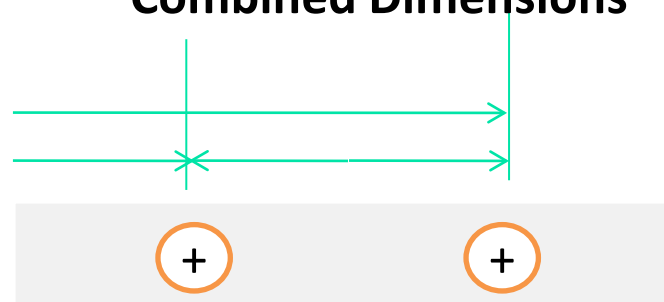
Chain Dimensions



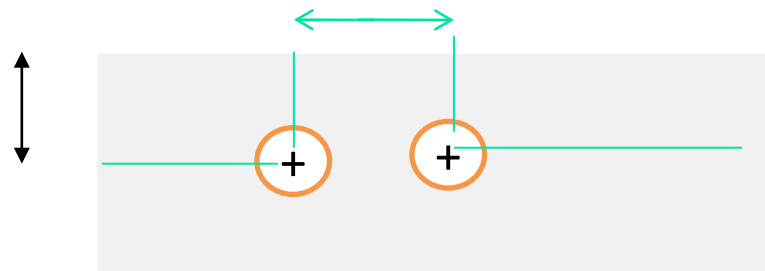
Super imposed Dimensions



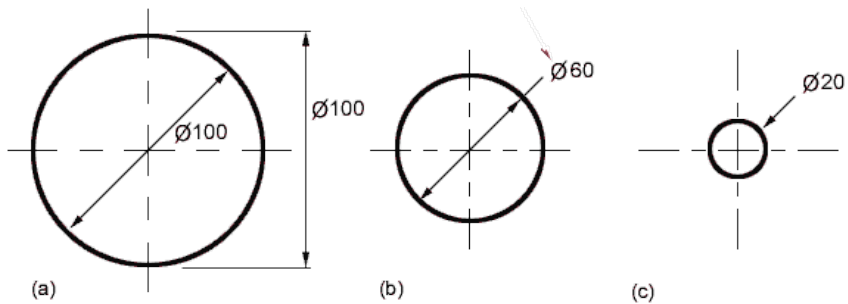
Combined Dimensions



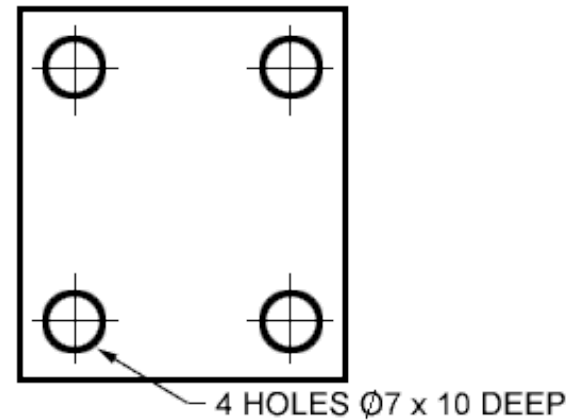
Co ordinate Dimensions



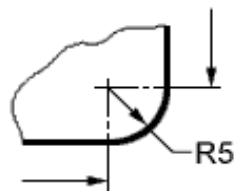
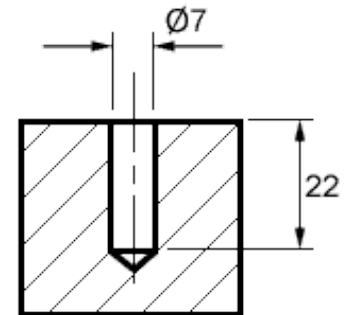
DIMENSIONING FEATURES



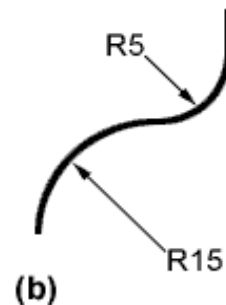
Circles



Holes



(a)



(b)

Radii

TOLERANCES

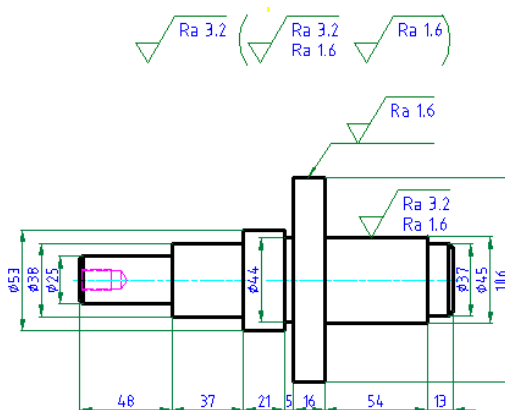
The maximum permissible variation from the dimension

Dimensional Tolerances

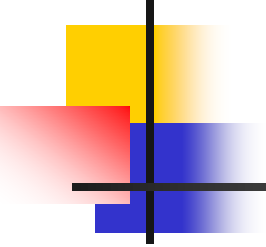
+

-

Geometric Tolerances

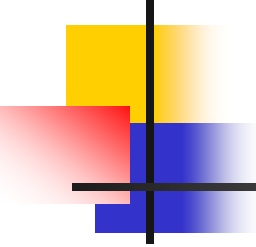


TYPE OF TOLERANCE	CHARACTERISTIC	SYMBOL
FORM	STRAIGHTNESS	—
	FLATNESS	
	CIRCULARITY (ROUNDNESS)	
	CYLINDRICITY ANGULARITY	
ORIENTATION	PERPENDICULARITY	
	PARALLELISM	



TYPES OF DRAWINGS

- Layout
 - Placements
- Working
 - Assembly parts
- Schematic/
diagrammatic
 - Using symbols



PRODUCING DRAWINGS

- **Manual or with drawing instruments and Other aids such as templates and appliqués,**
- **Free hand with pencil on paper or with automated devices like computers.**

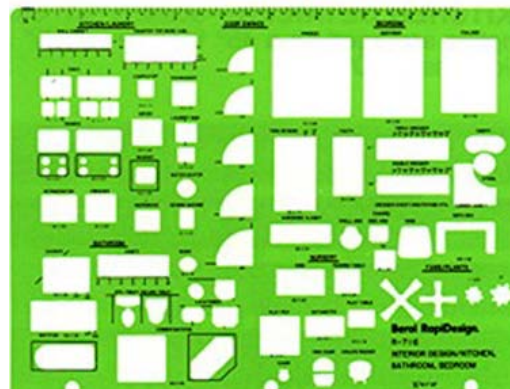
Hand Drawing

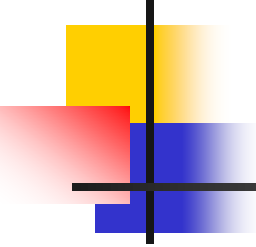
- Pencils
- Pens/Inks
- Chalk Crayons
- Drawing Papers and Surfaces
- Drawing Tools and Accessories
- Erasers



Drawing Tools and Accessories

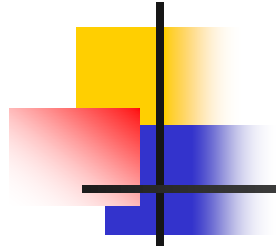
- Compasses
- Curves
- Drawing Boards
- Lettering Stencils and Guides
- Parallel Rules
- Protractors, Triangles, and Corner Squares
- Rulers and Measurement Tools
- T-Squares
- Templates



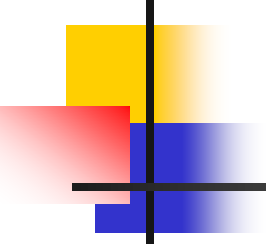


MODERN AIDS

- Computer Software
- Computer Aided Design - CAD



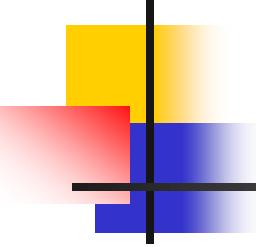
SELECTION OF MATERIALS



Classification of Materials

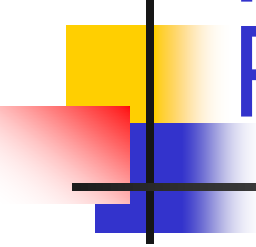
Based on the specific application

- Structural materials (mechanical parts)
- Functional materials (electrical, optical, magnetic, ...)



REQUIREMENTS OF STRUCTURAL MATERIALS

- **Stiffness** Resistance to elastic deformation (wood V/S plastic)
- **Strength** Resistance to plastic deformation (metal V/S a plastic)
- **Toughness** Resistance to fracture (plastic ruler V/S wood or metal)



REQUIREMENTS OF FUNCTIONAL MATERIALS

Electrical materials

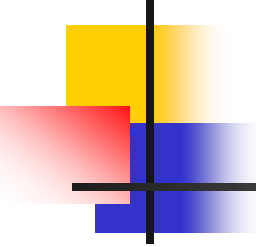
Conductors, insulators, dielectric ...

Magnetic materials

Remanence, saturation magnetization ...

Optical materials

Transmission, reflection, refraction



CLASSIFICATION OF ENGINEERING MATERIALS

■ **Metals and Alloys:**

Ferrous Metals Possess good functional and structural properties

Examples

Low, Medium and High Carbon Steels (0.30to ~2.0%)

Stainless Steel containing at least 10.5% chromium.

Non-Ferrous Metals Possess good functional properties

Examples

Aluminum / Aluminum alloys, Brass (copper and zinc, 65% to 35%) Bronze

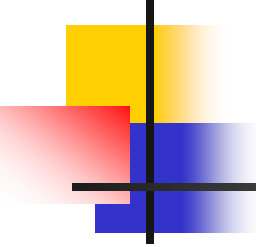
■ **Ceramics and Glasses:**

Withstand High temperature , usually very brittle and poor electrical conductors

Examples

Crystalline (ceramics)- Alumina, Zirconia.

Non-crystalline (glasses)-



ENGINEERING MATERIALS

- **Polymers:** **Non-crystalline Organic materials containing carbon.**

Most polymers are poor electrical conductors but corrosion resistant.
Examples
Thermoplastic. Formed into desired shapes under heat and pressure.
(PVC), polycarbonate (PC), and polystyrene (PS). polyethylene (PE),
polypropylene (PP), polyester
Thermosetting materials. Formed into desired shapes under heat
Examples
- **Composites:** **High stiffness, High strength and High temperature performance**

Materials where two or more of the above materials are brought together on macroscopic level.
Usually they consist of a matrix and a reinforcement.
Example

Metal-matrix composites	(MMC)
Polymer-matrix composites	(PMC)
Ceramic-matrix composites	(CMC)

Periodic Table of Elements

IA		Metals										Non Metals										Metalloids					0		
1	H	IIA																						2	He				
3	Li	4	Be																										
11	Na	12	Mg	IIIB	IVB	VB	VIB	VII B	VII		IB		IB	5	6	7	8	9											
19	K	20	Ca	21	Sc	22	Ti	23	Y	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	13	14	15	16	17	18
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	50	51	52	53	54
55	Cs	56	Br	57	La*	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	82	83	84	85	86
87	Fr	88	Ra	89	Ac*	104	Rf	105	Ha	106	106	107	107	108	108	109	109	110											

*Lanthinide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	Lu
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

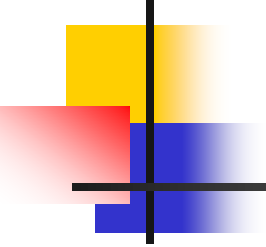
*Actinide Series

90	91	92	93	94	95	96	97	98	99	100	101	102	Lr
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Alkali metals

Alkaline earths

Gases



MATERIALS SELECTION CRITERIA

1. Engineering considerations(Strength, durability..)
2. Cost
3. “Green” ?
4. Easy commercial availability
5. Political (Sanctions on nuclear materials)
6. Technology (Cryogenic engines, ...)

Materials property charts

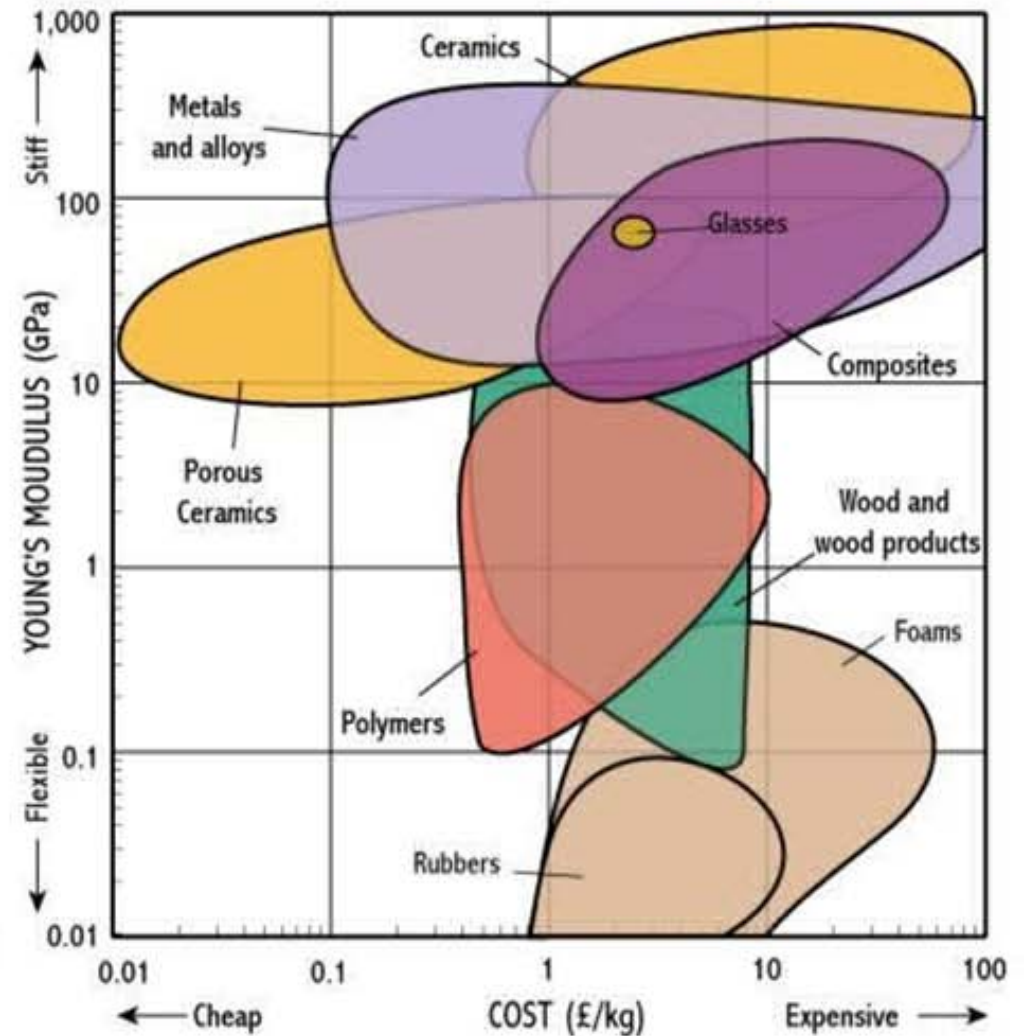
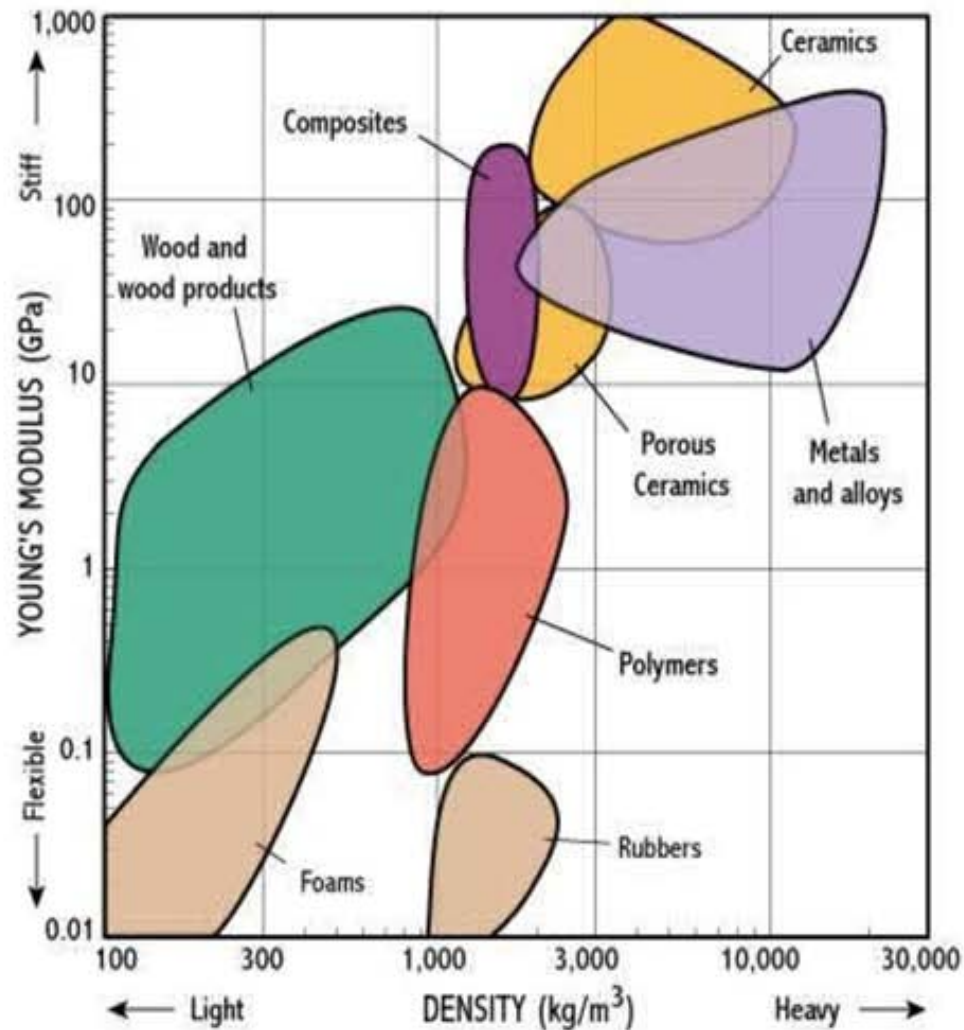
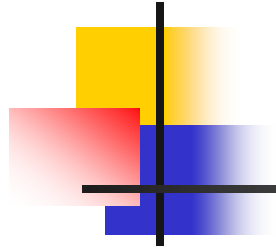
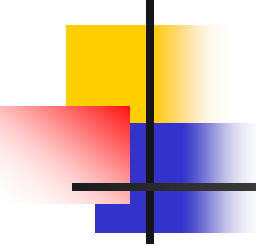


Image courtesy: University of Cambridge homepage

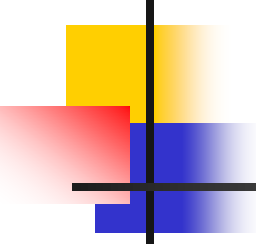


Manufacturing



MANUFACTURING PROCESSES

- Melting & Casting
- Bulk forming
- Machining
- Sheet Metal Forming
- Joining



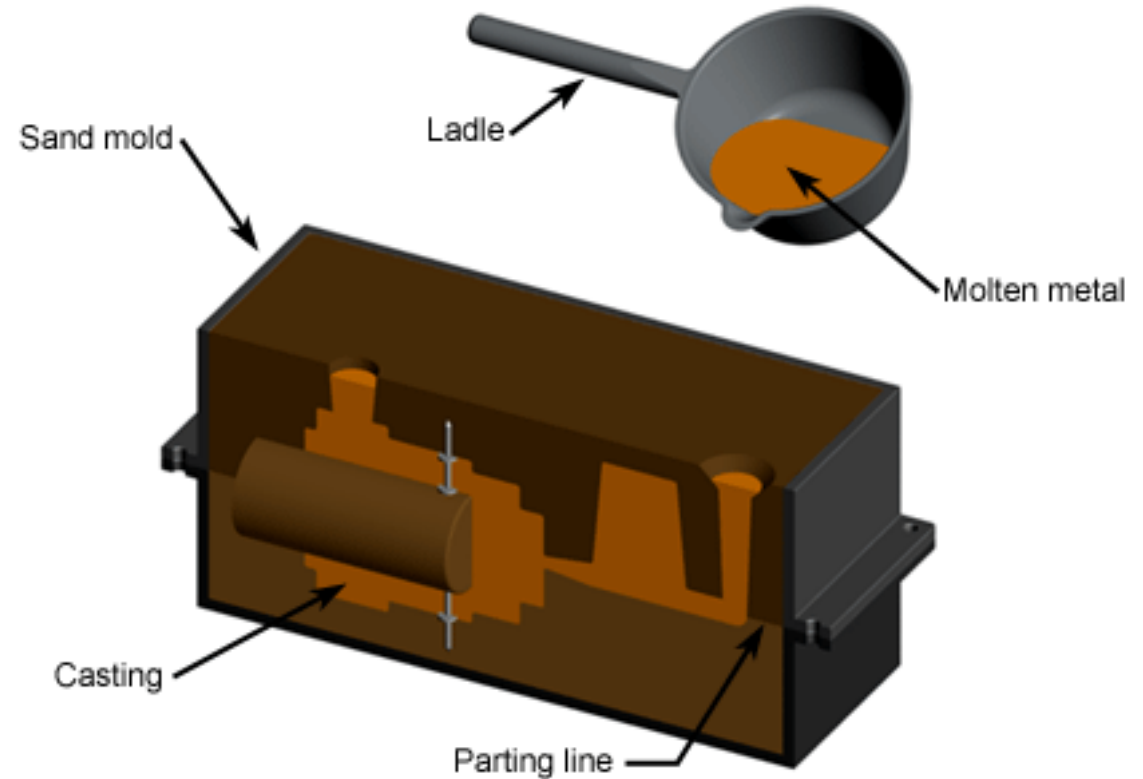
MELTING & CASTING

- The first step in manufacturing.

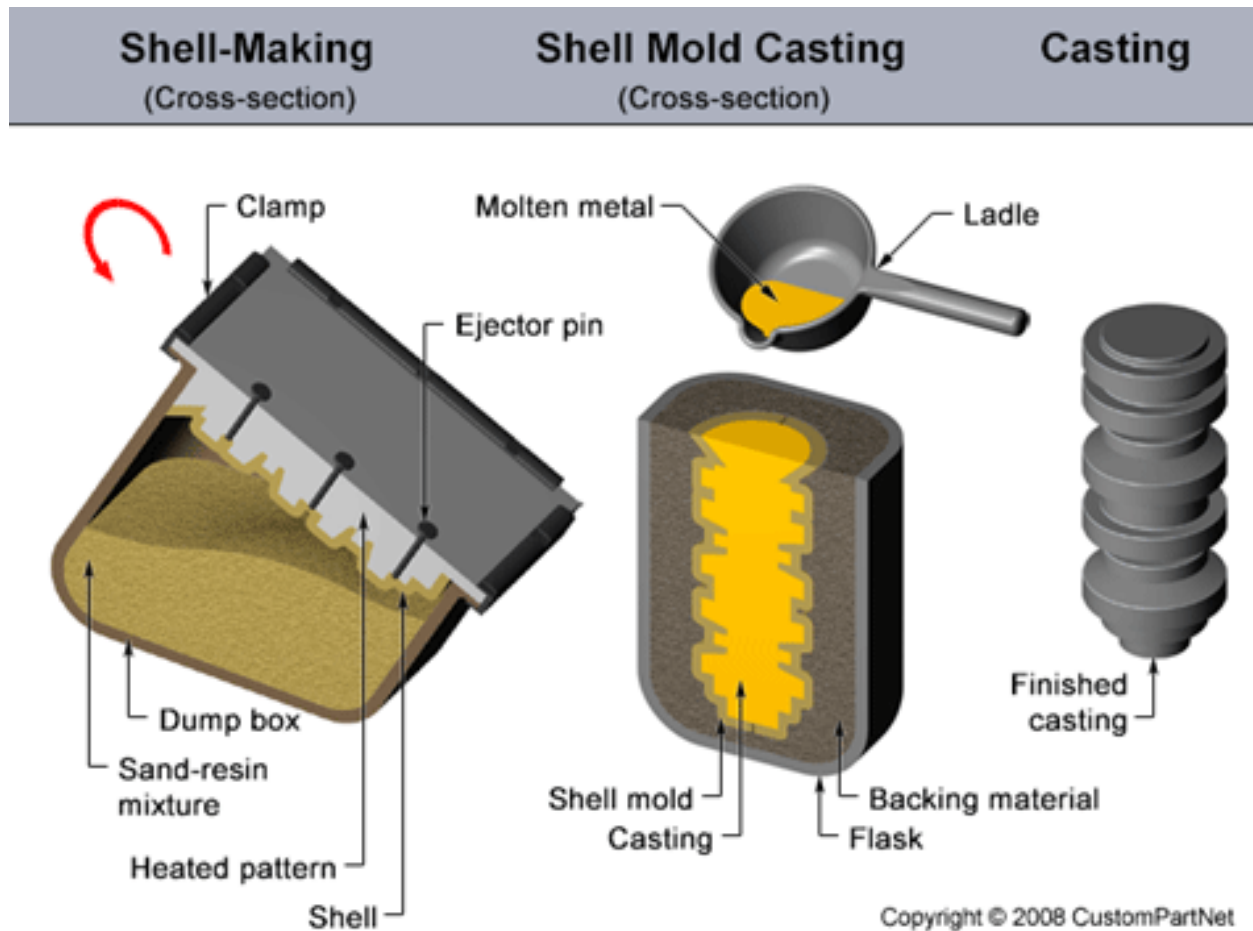
In casting, a material in liquid form is poured into a mold where it is allowed to solidify by cooling (metals) or by reaction(plastics).

Sand casting

- Sand casting is used to make large parts (typically Iron, but also Bronze, Brass, Aluminum).

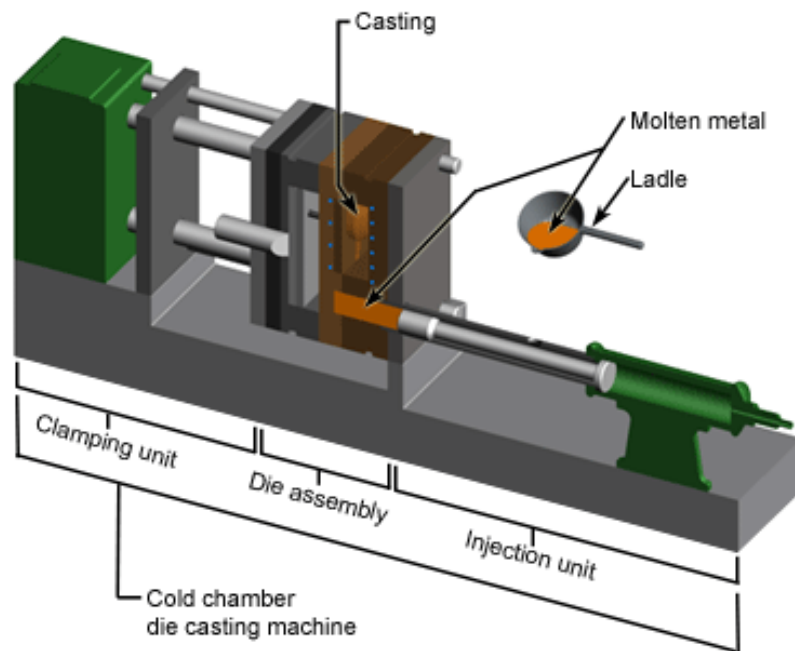


Shell Mould Casting

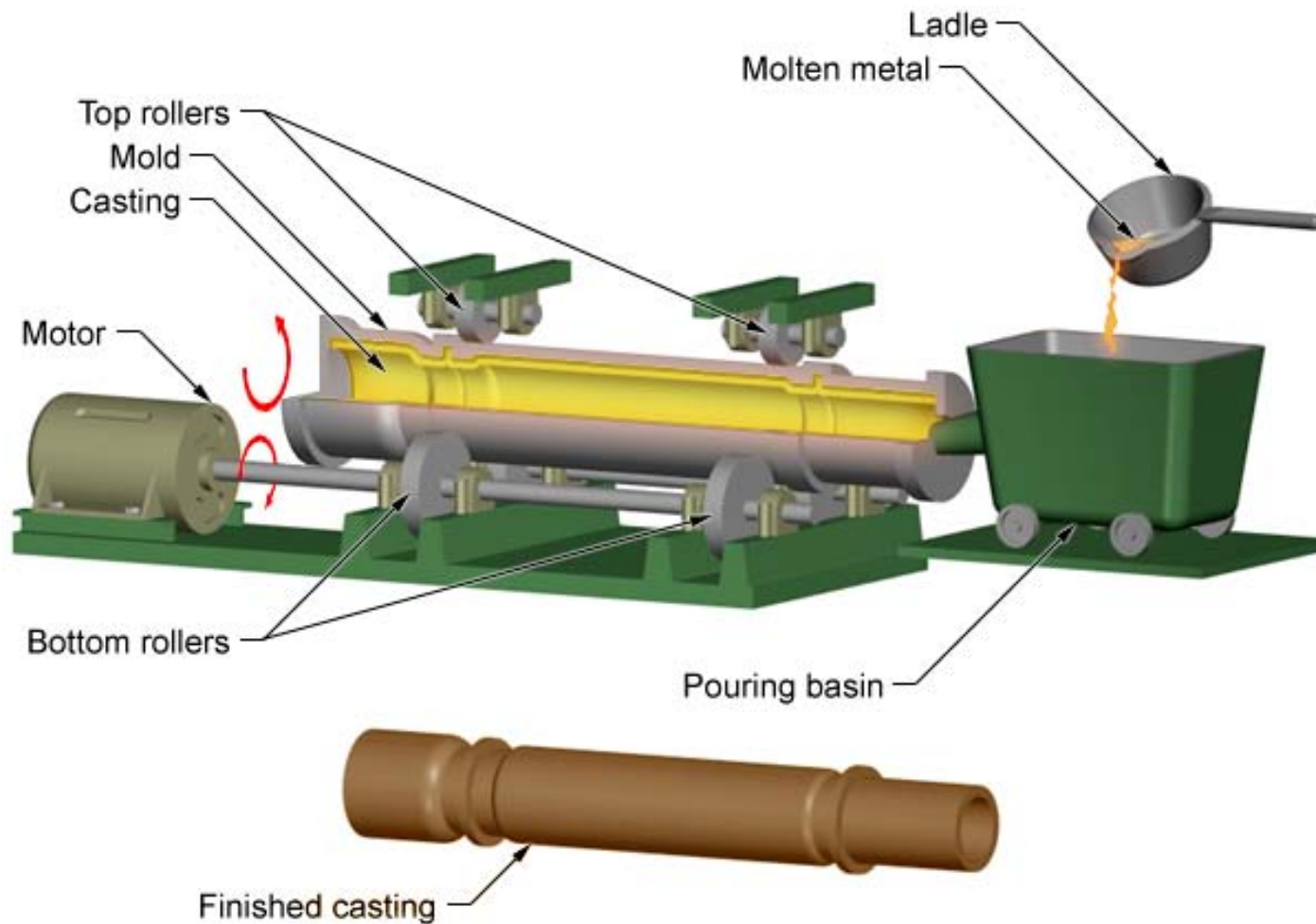


Die-casting

In Die-casting the metal is injected into the mold under high pressure



Centrifugal Casting



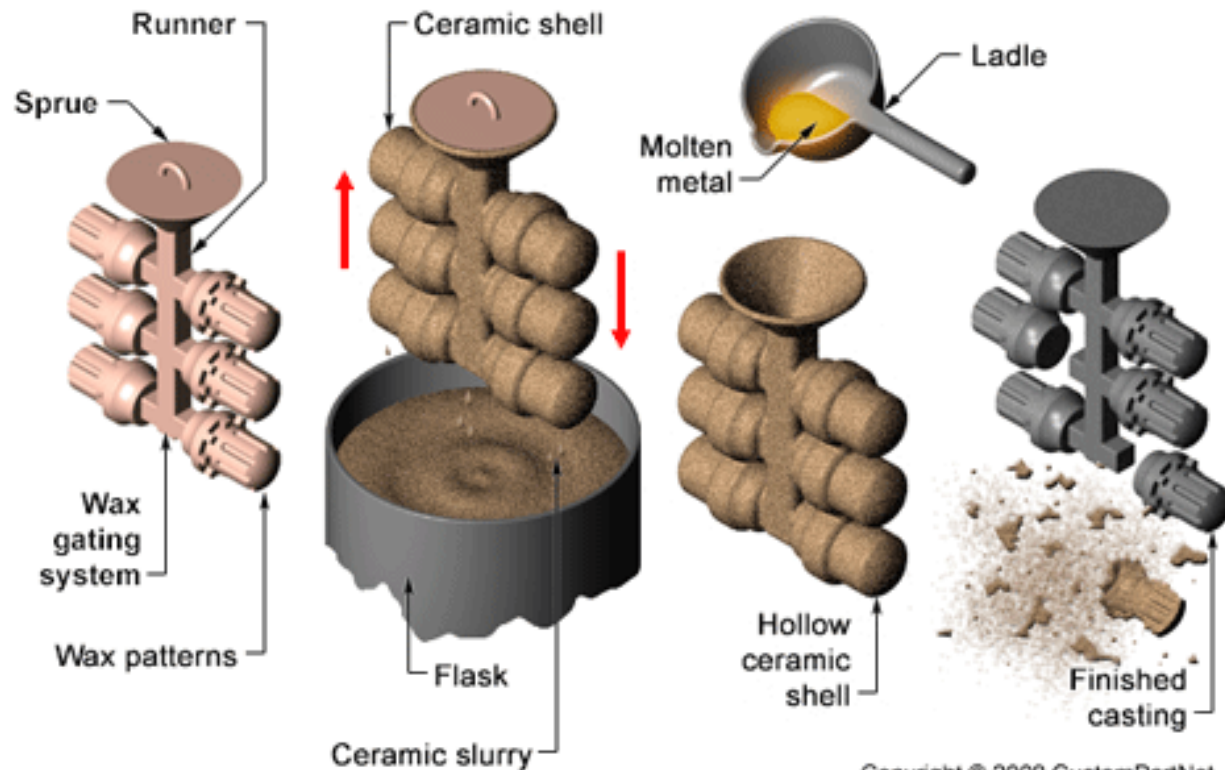
Investment Casting

Pattern Tree

Shell-Making

Investment Casting

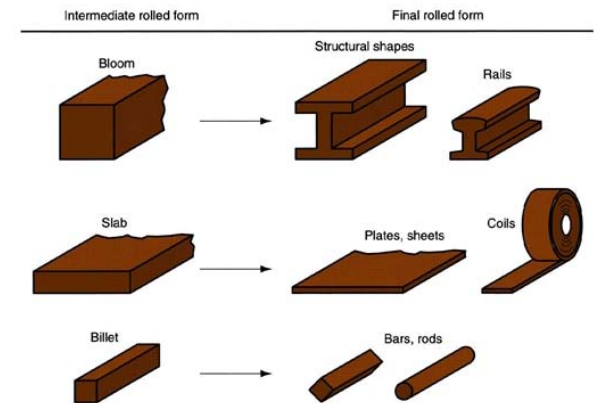
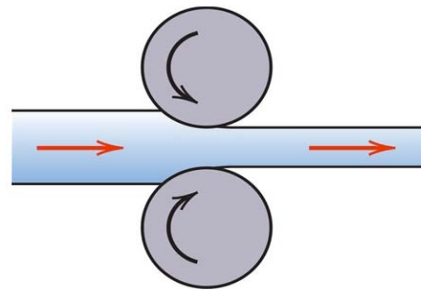
Casting



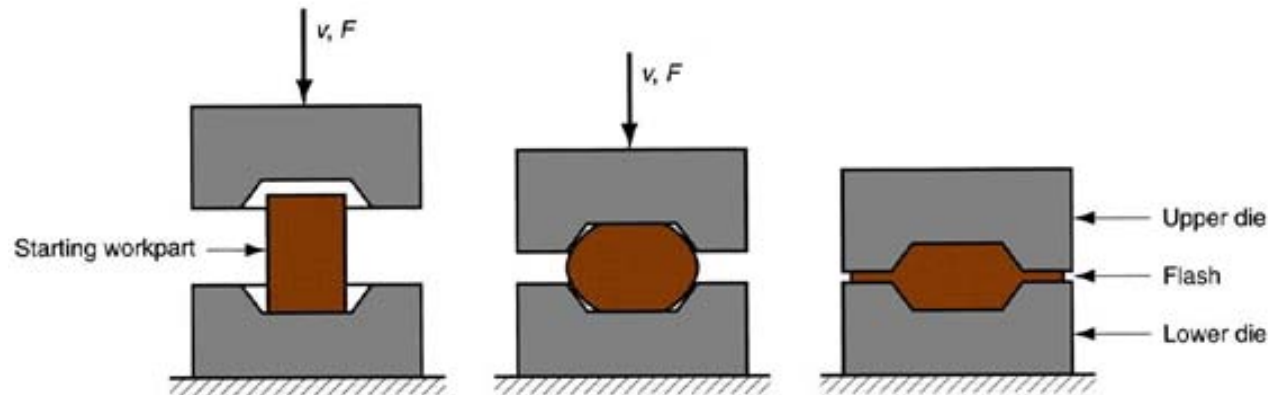
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Bulk Forming

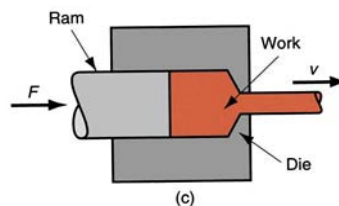
■ Rolling



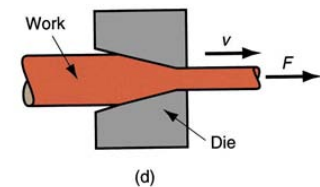
■ Forging



■ Extrusion



Drawing



Various Mills



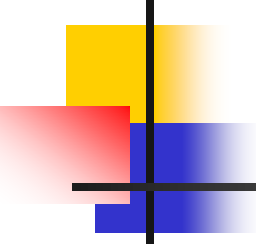
A small rolling Mill



A Hammer Mill

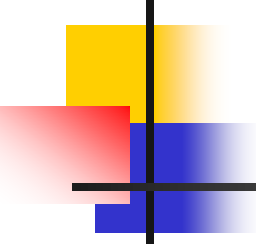


An extrusion Mill



Machining

- The process of removing material from a work piece in the form of chips
- A machining process requires a cutting tool & a machine

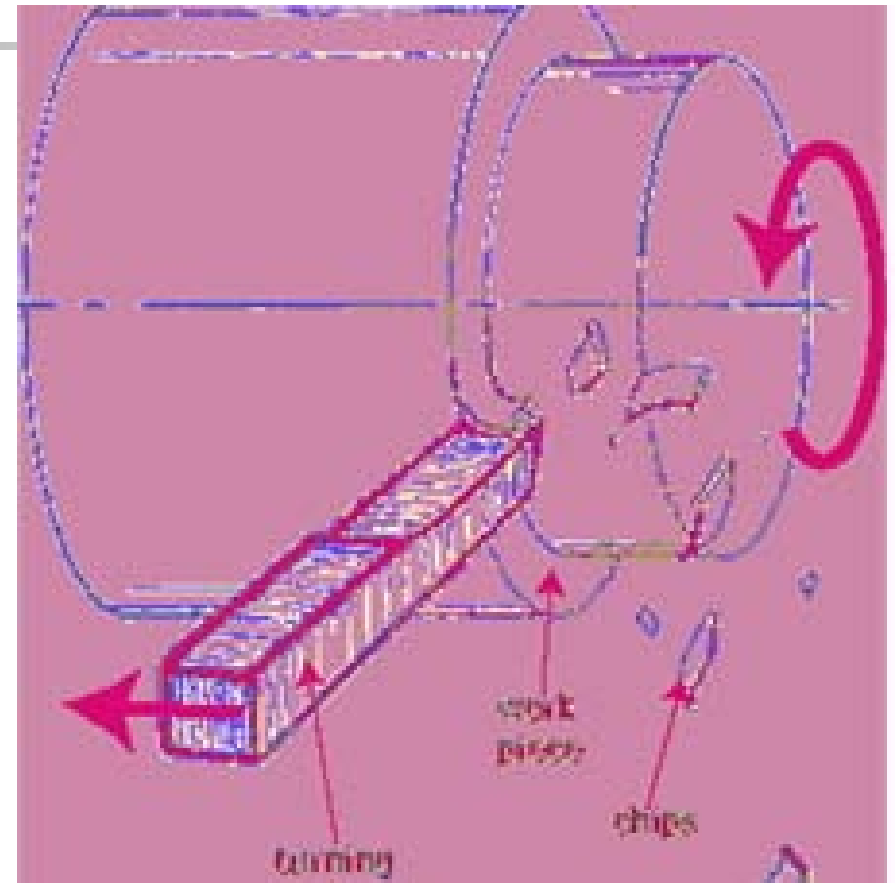
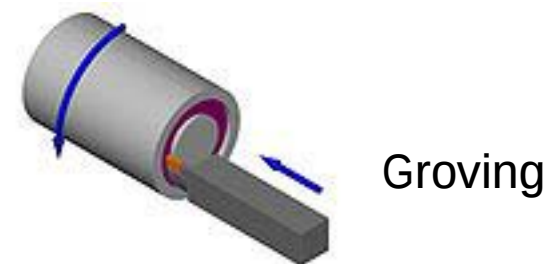
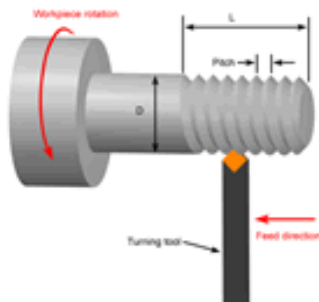
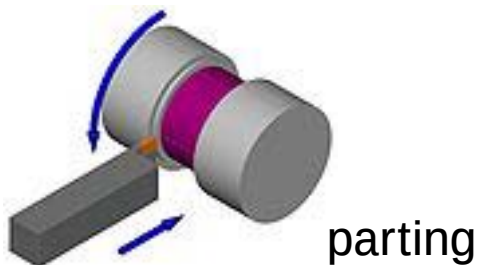
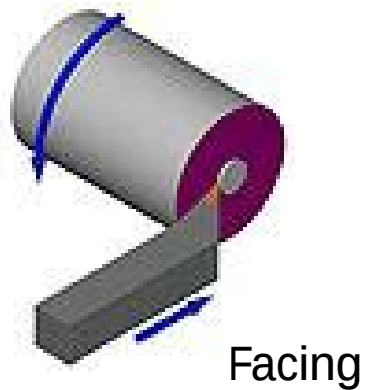
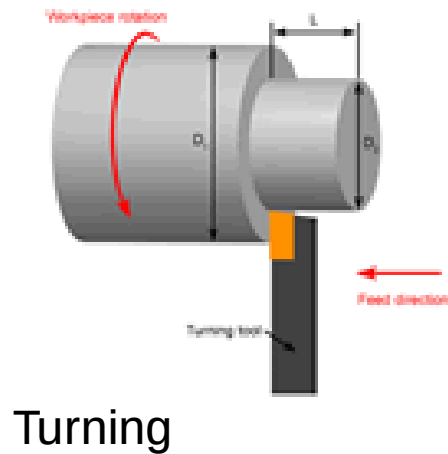


Machining Processes

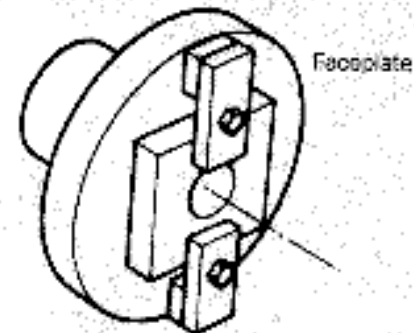
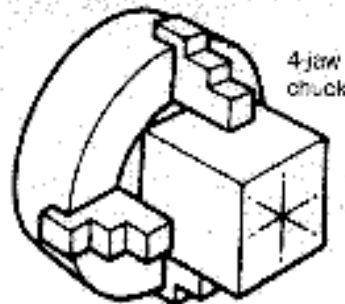
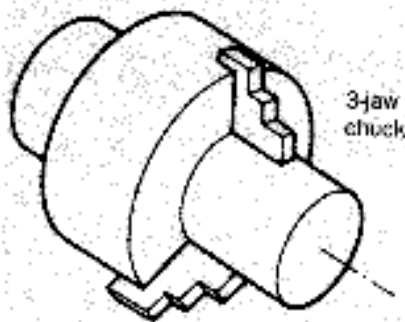
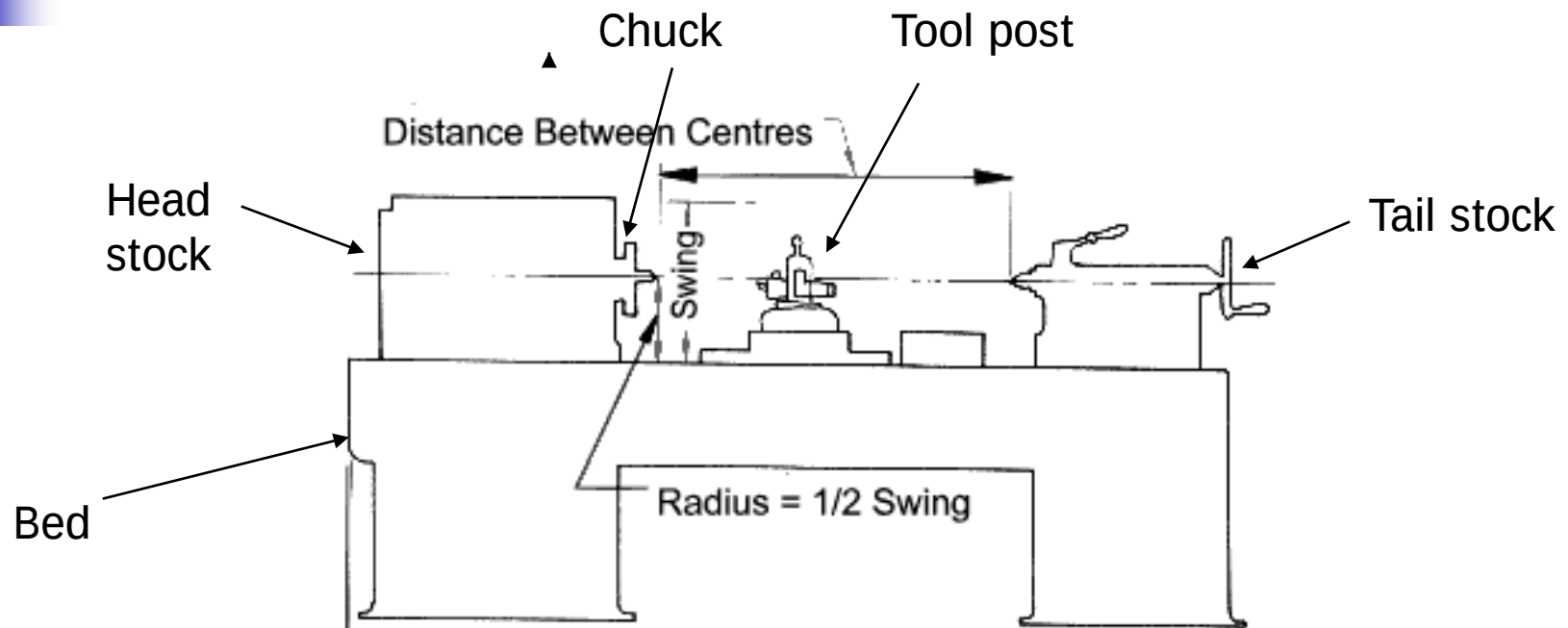
- Turning
- Milling
- Drilling
- Shaping / Planing.
- Sheet Metal Forming
- Joining

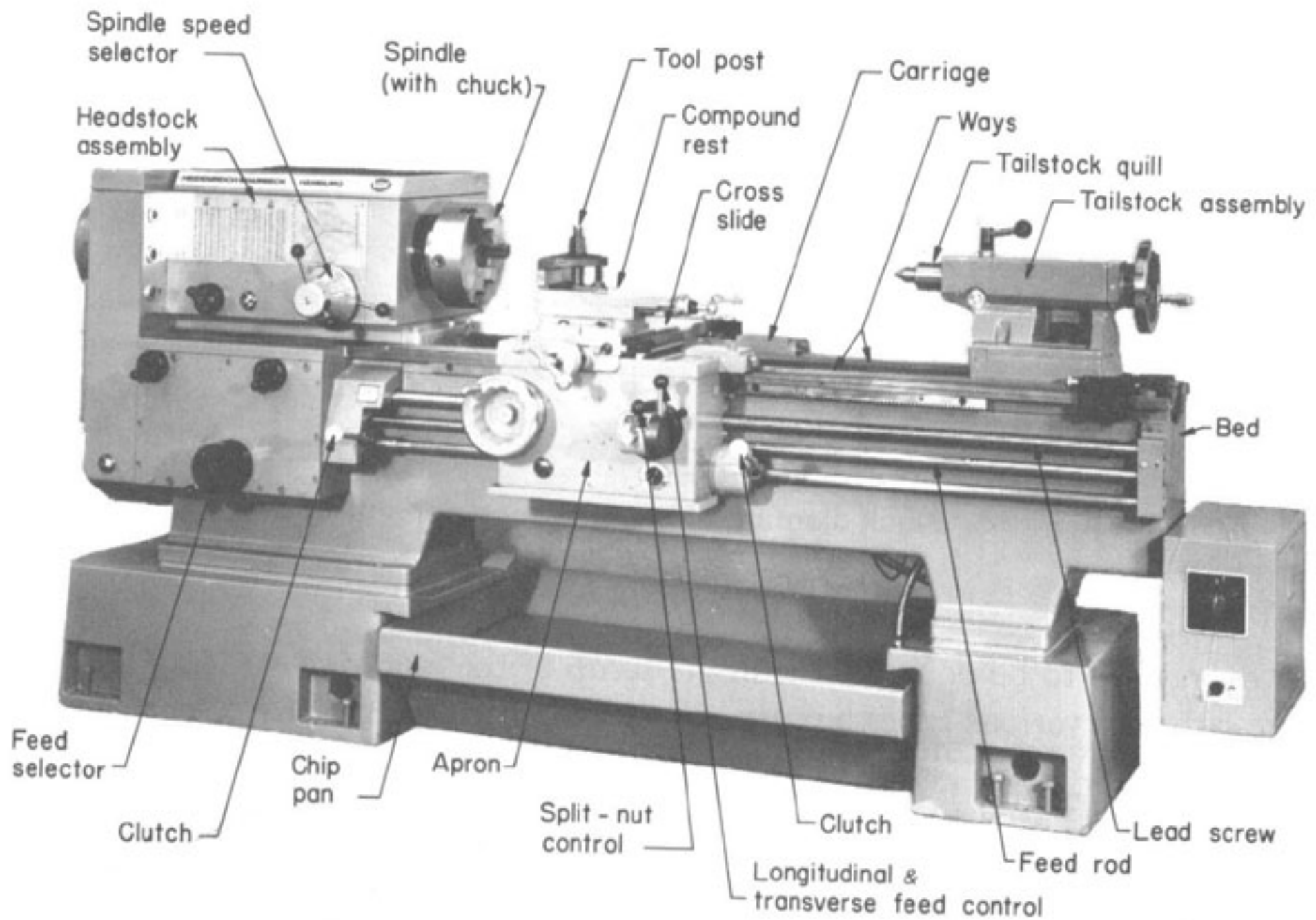
Turning

Turning is performed on a lathe machine



Definition of a Lathe Machine





Parts of a Lathe Machine

Head Stock



Carriage



Tail Stock



www.machinetoolsupplier.com

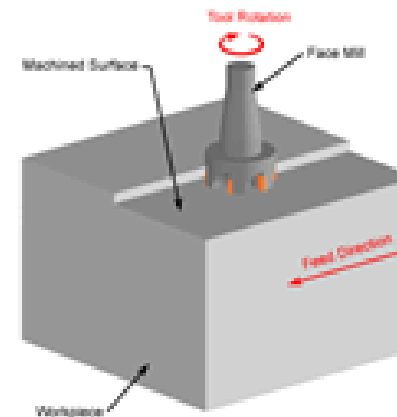
A CNC Lathe Machine



-



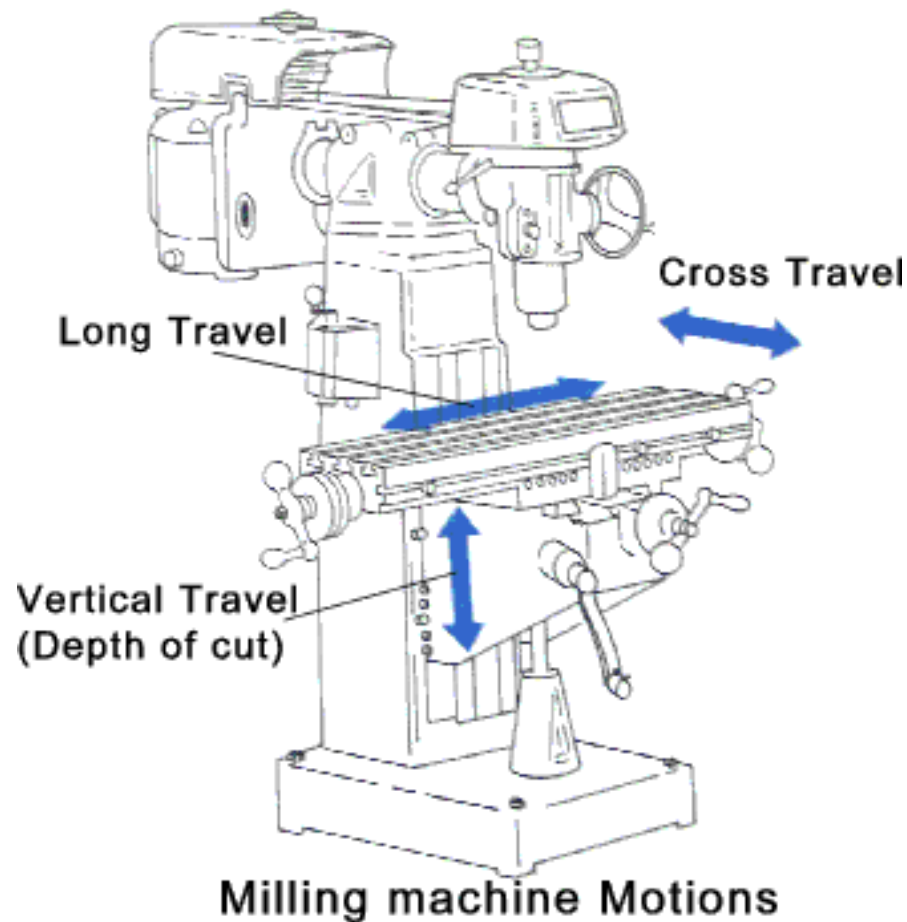
The diagram illustrates a ball end mill machining process. A vertical ball end mill is shown cutting into a rectangular workpiece. A red circular arrow at the top of the tool indicates 'Tool Rotation'. A red arrow pointing to the right along the front face of the workpiece indicates 'Feed Direction'. The top surface of the workpiece, which has been machined, is labeled 'Machined Surface'. The workpiece itself is labeled 'Workpiece'. The tool is labeled 'Ball End Mill'.



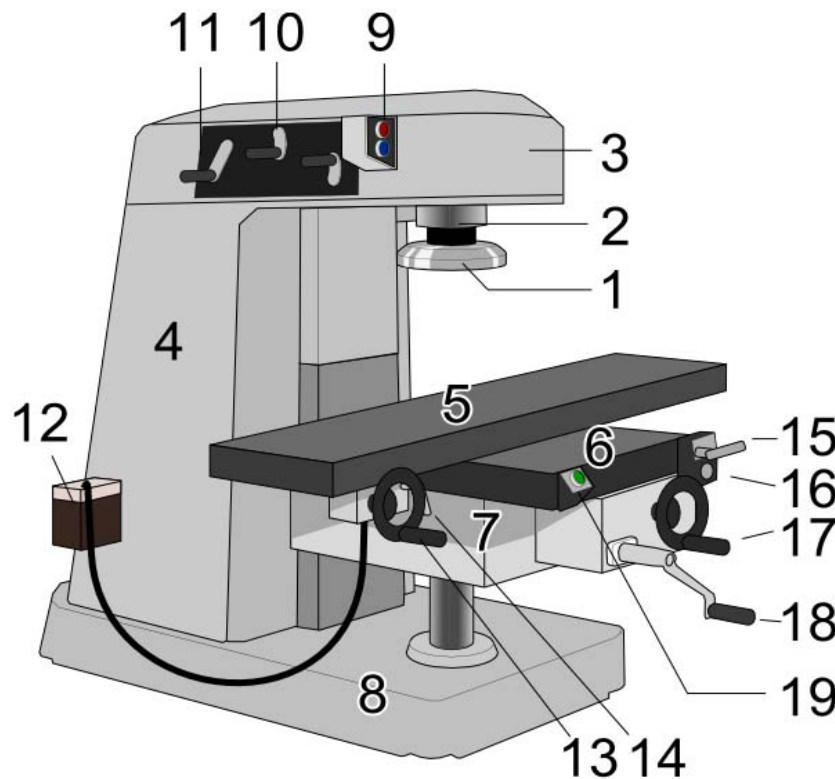
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A SIMPLE MILLING MACHINE



Milling Machine Parts



- 1.Face milling cutter**
- 2.Spindle**
- 3.Spindle head**
- 4.Column**
- 5.Table**
- 6.Saddle**
- 7.Knee**
- 8.Base**
- 9.Spindle switch**
- 10.Spindle speed gear lever**
- 11.Spindle speed control lever**
- 12.Oil tank**
- 13/14. Transverse motion**

Milling Tools

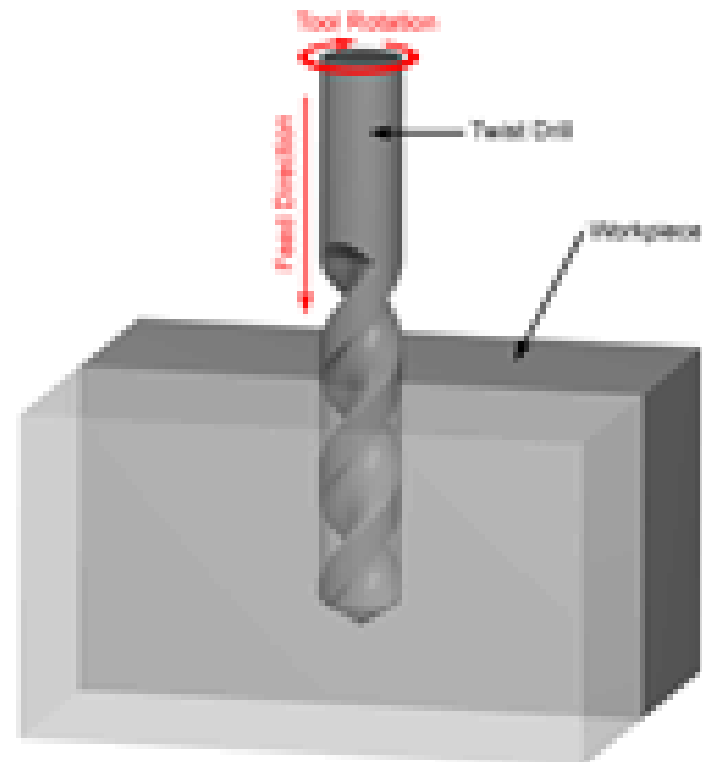
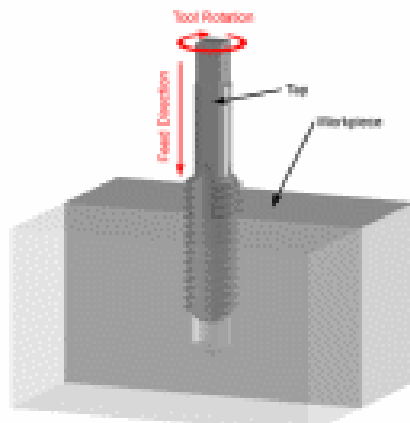


CNC Milling Machine



Drilling

Drilling is a process used to produce holes inside solid parts.



A SIMPLE DRILL MACHINE



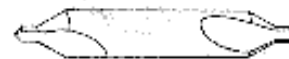
TAPER SHANK DRILL



STRAIGHT SHANK DRILL

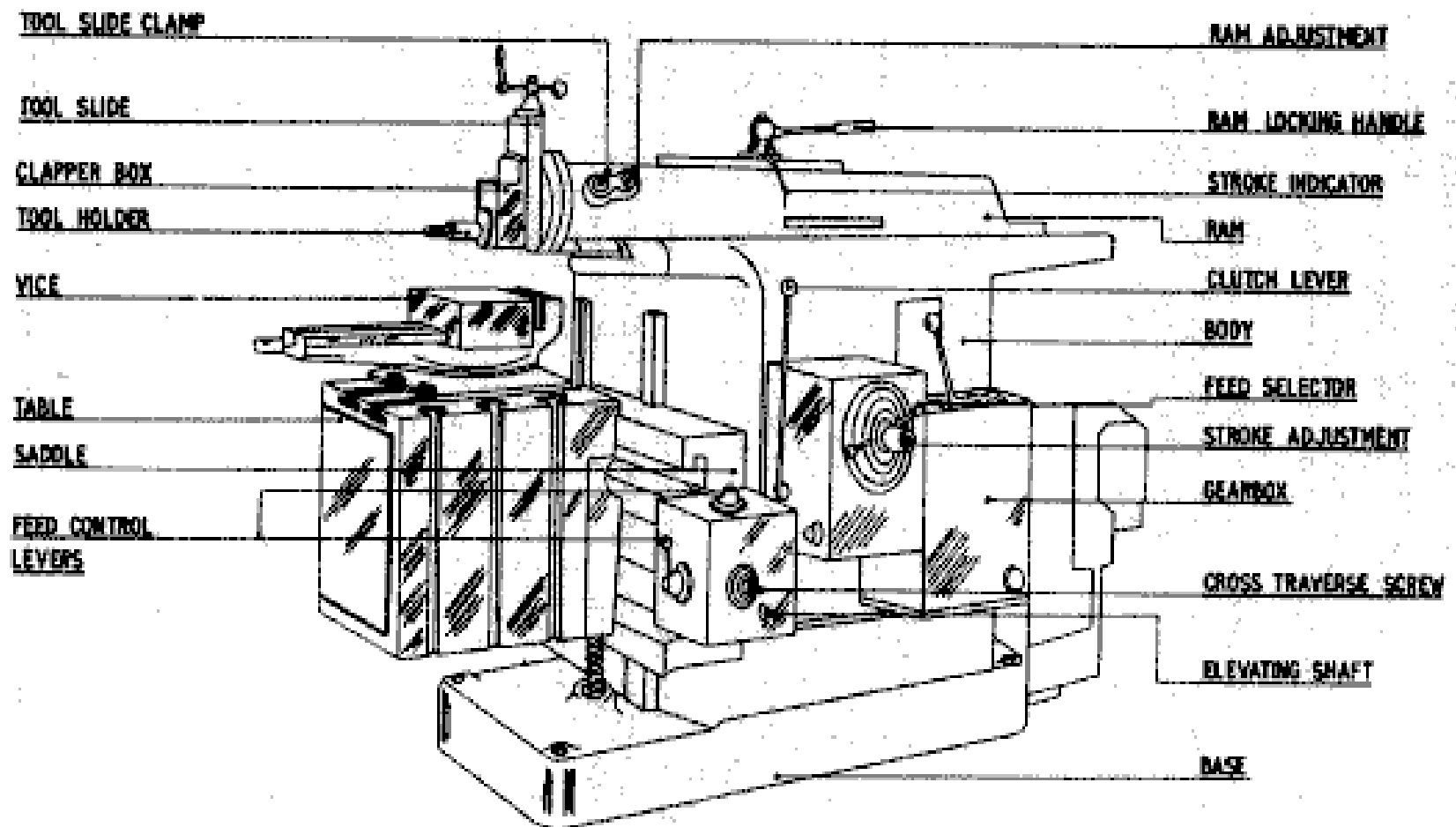


SPOT FACE DRILL



CENTER DRILL

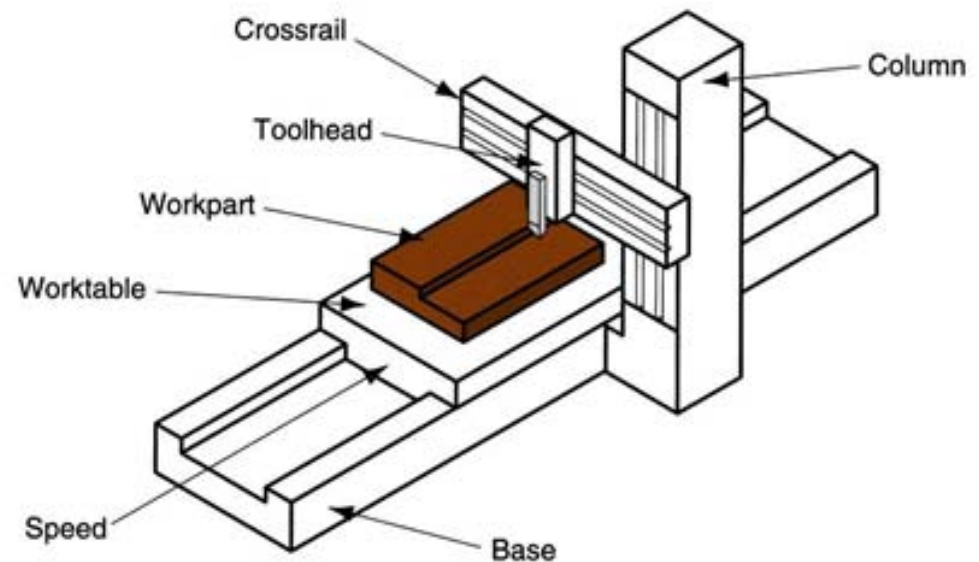
Shaper machine

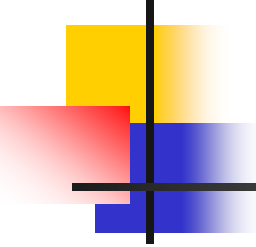


SHAPER

Shaping Machine

Shaping is used to produce surfaces.





Sawing

Cutting process

- Wood



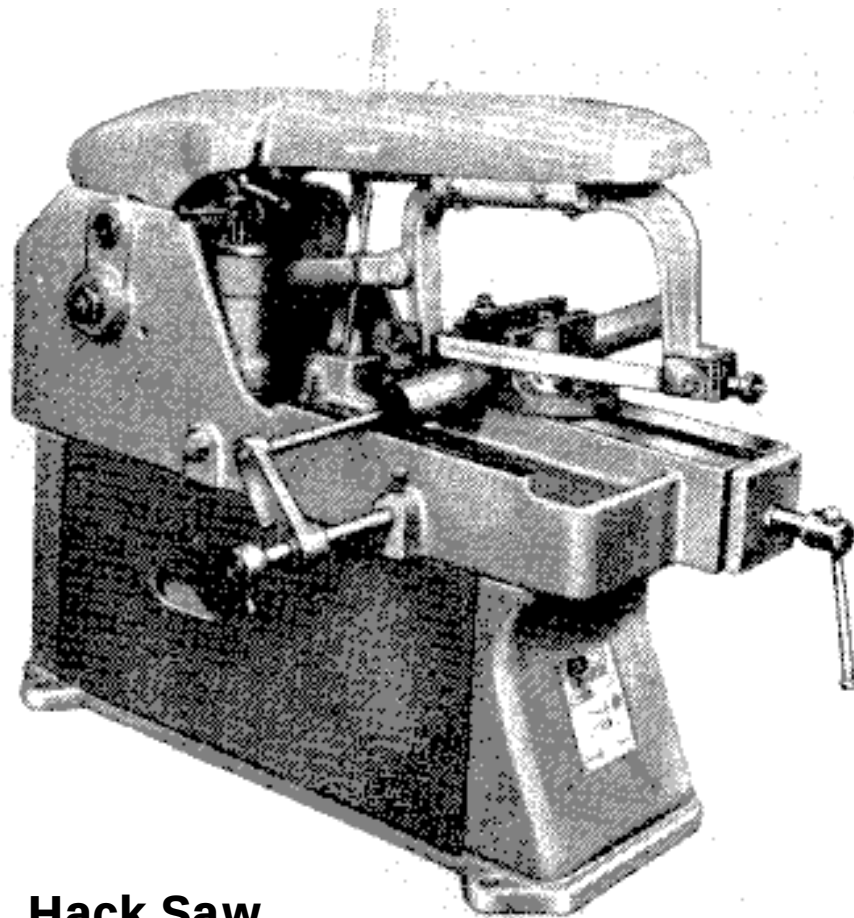
- Metal



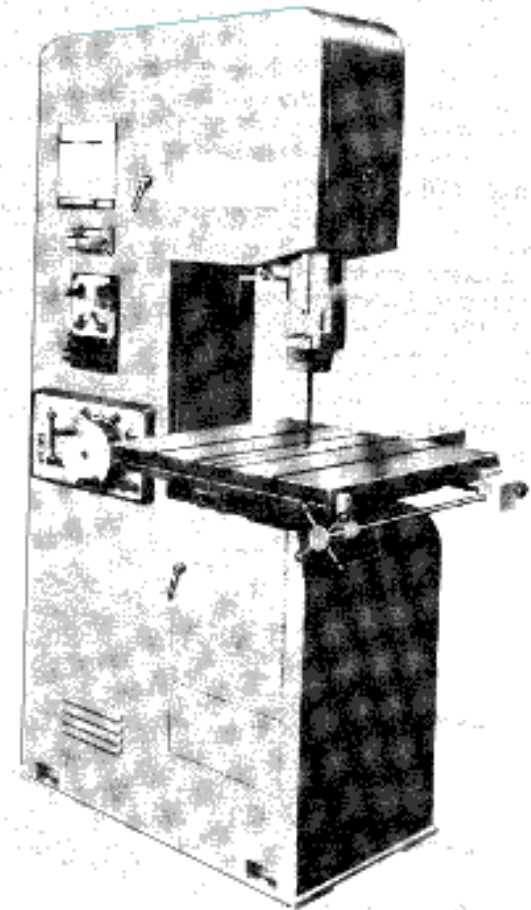
- Glass



Sawing Machines

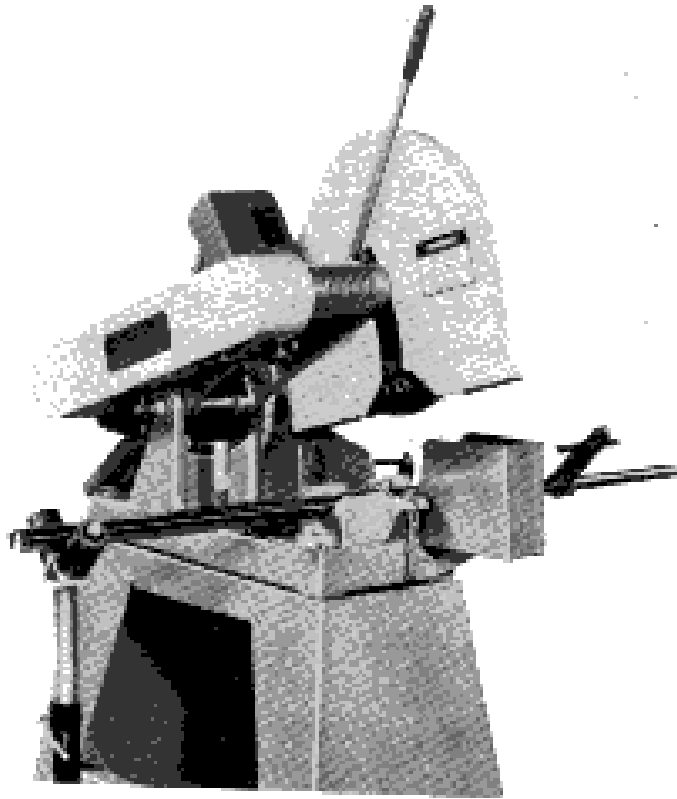


Hack Saw



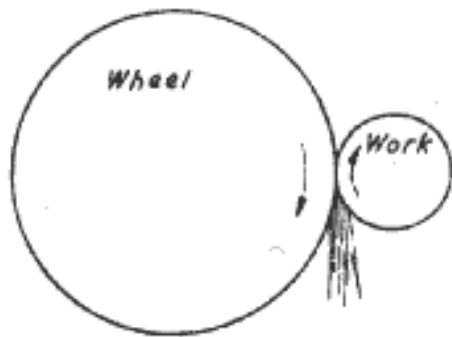
Band Saw

Abrasive Saw

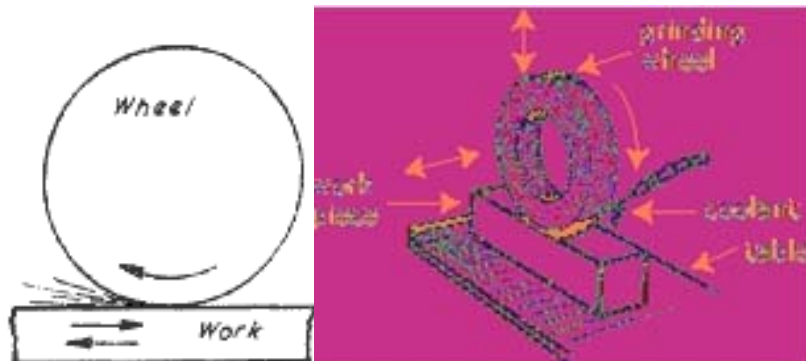


Abrasive cut off saw

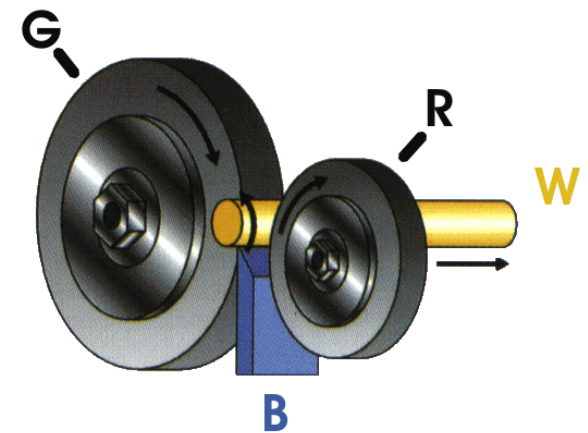
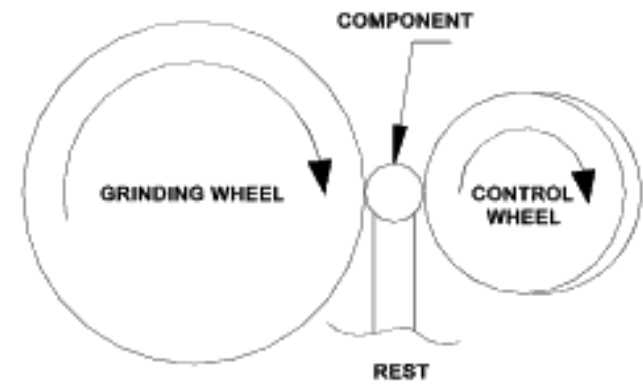
Grinding



Grinding Wheel

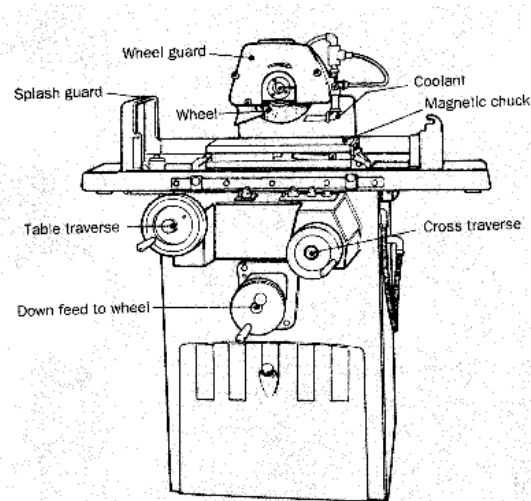


Surface Grinding

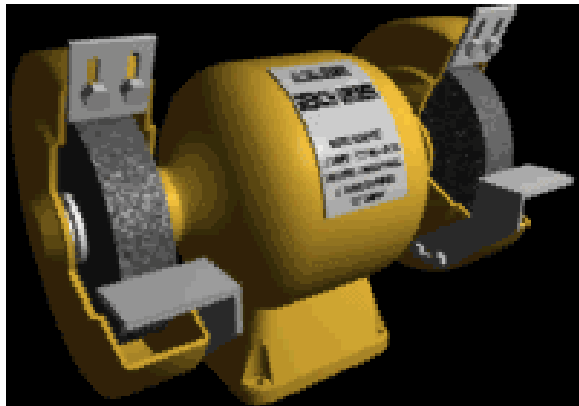


Centreless Grinding

Grinding Machines



Surface Grinder



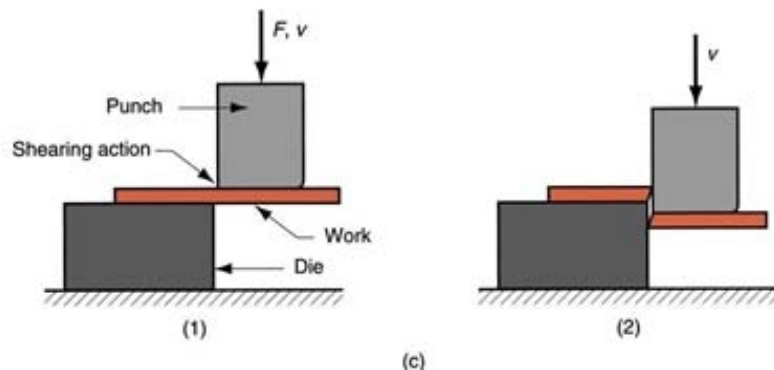
Wheel Grinder



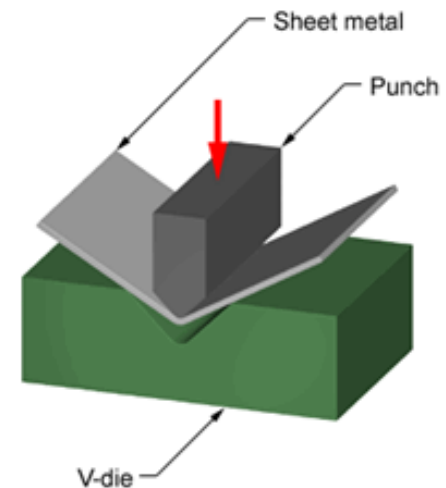
Centreless Grinder

Sheet Metal Forming

An important manufacturing process

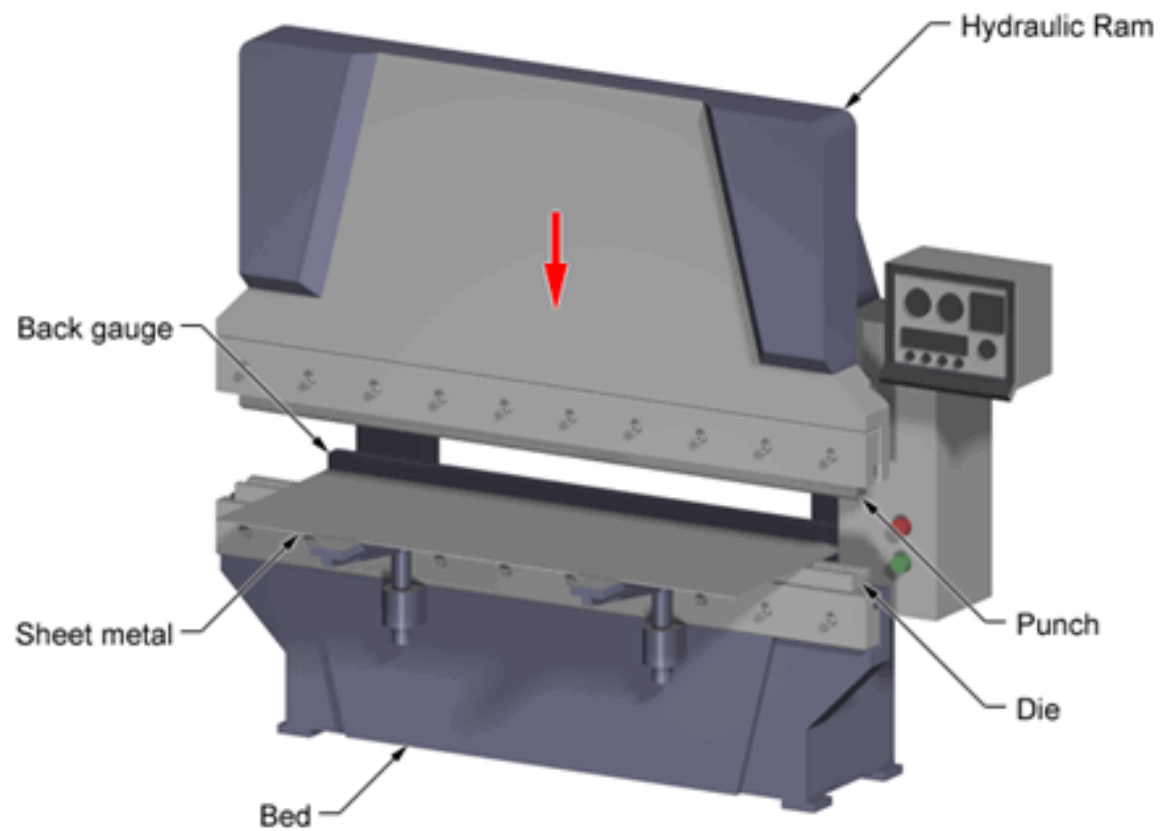


Sheet cutting

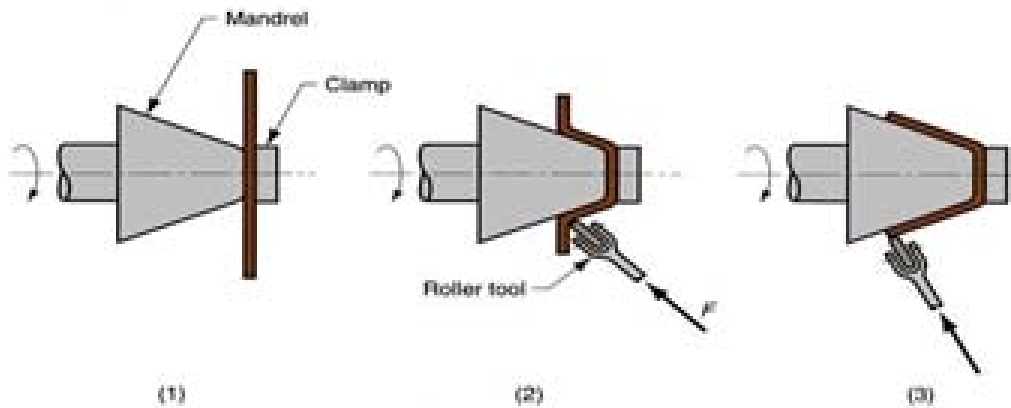
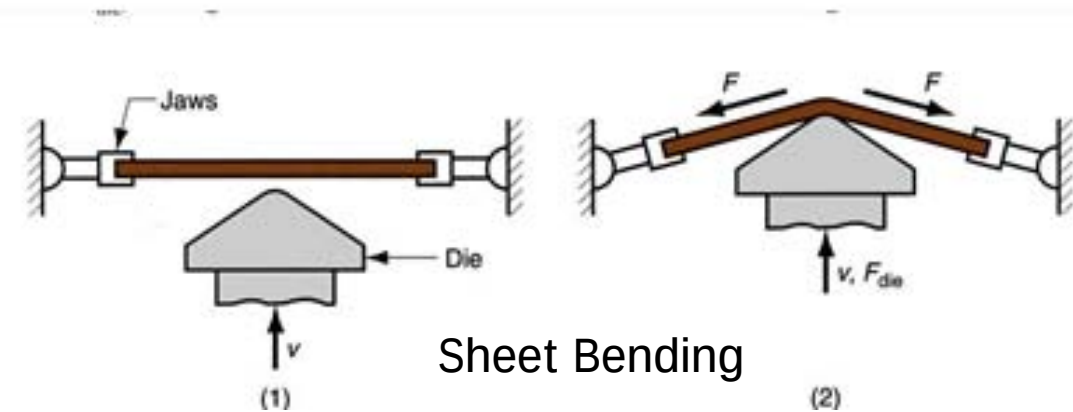


Sheet bending

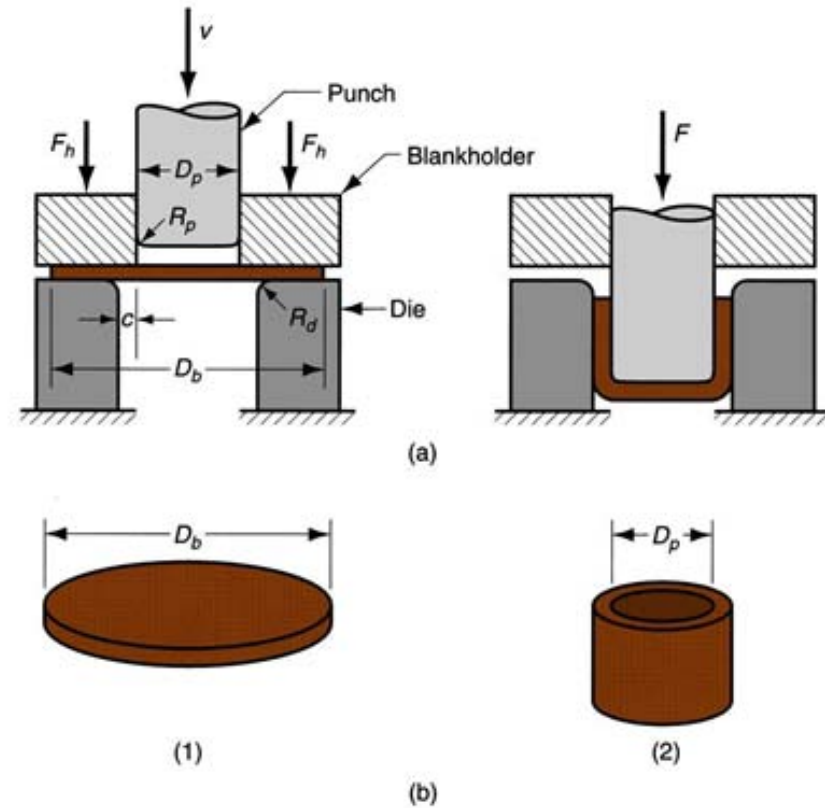
Press Break

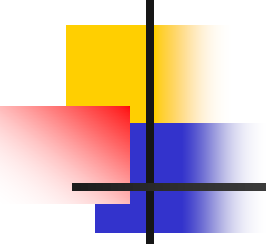


Sheet Metal Forming & drawing



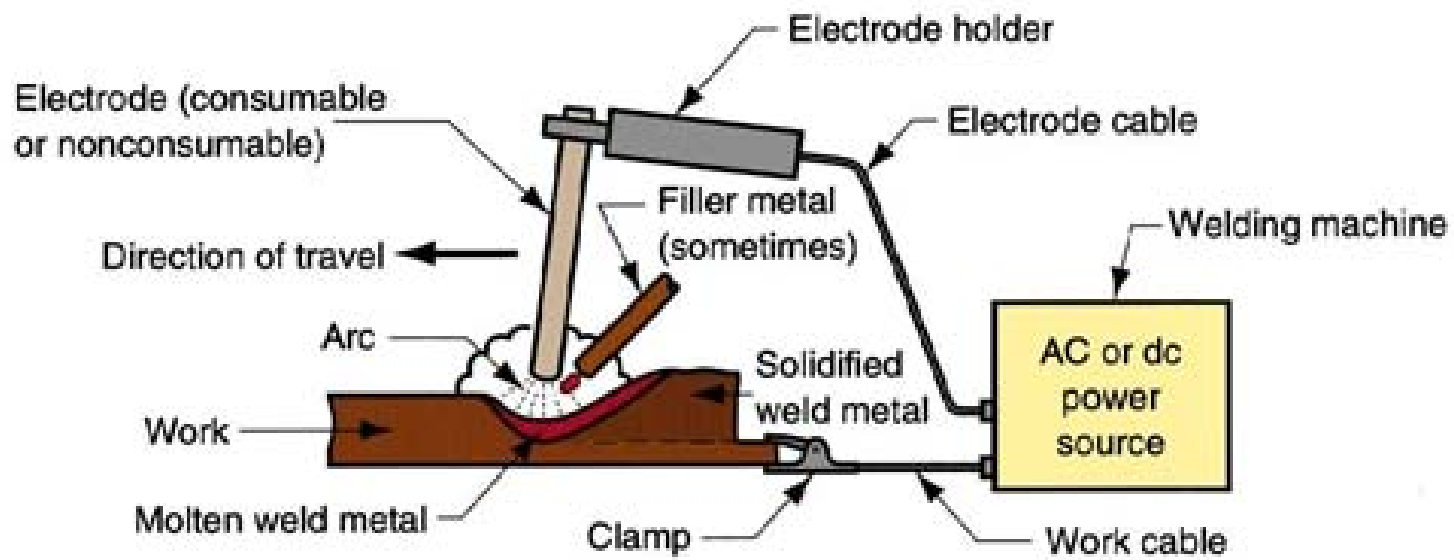
Forming



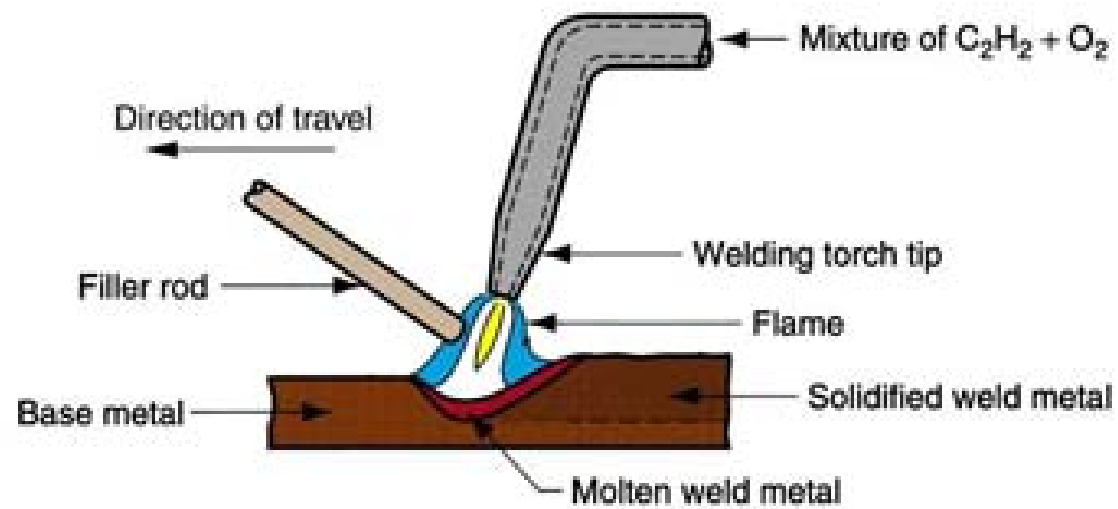


Welding

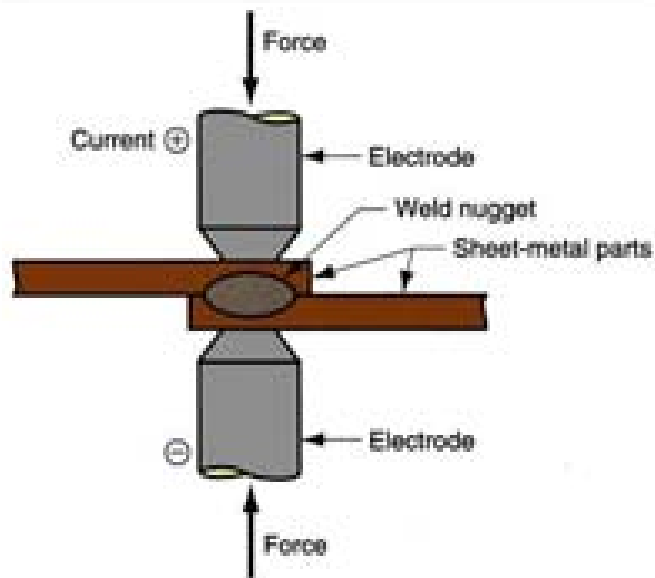
Permanently joining metal parts



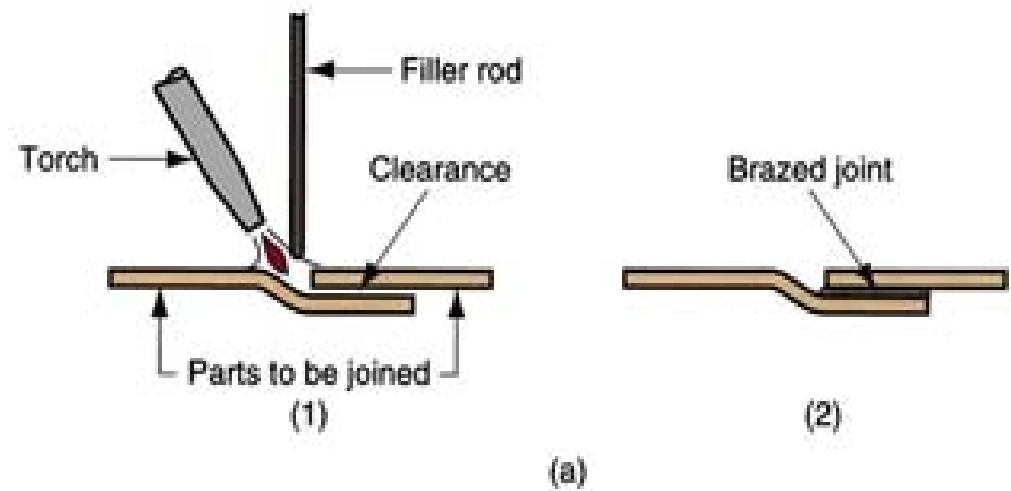
ARC Welding



Oxy Fuel Welding

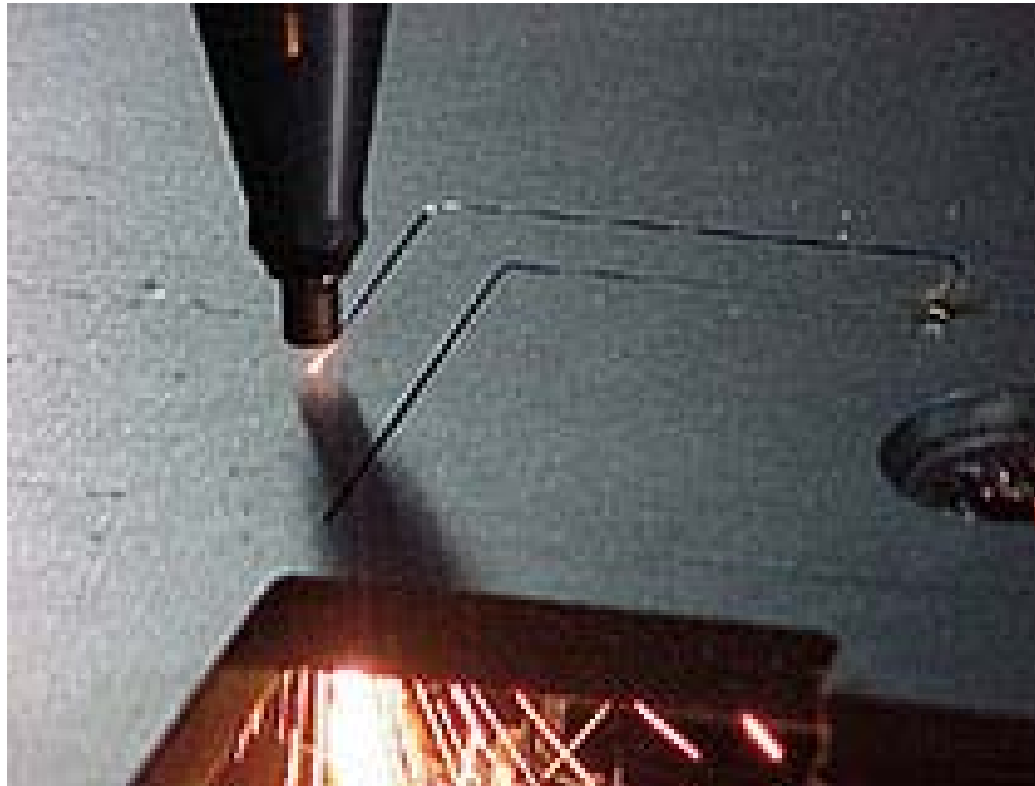


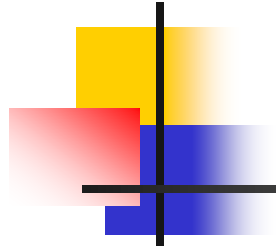
Resistance Welding



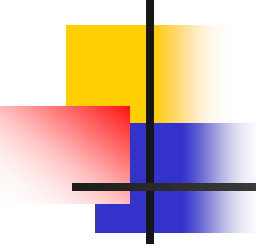
Brazing & Soldering

LASER PROCESSING





END SLIDE



Testing of Materials

Measuring hardness

- Mohs  Historical interest
- Brinell  Macro tests
- Rockwell  Macro tests
- Vickers  Micro tests
- Knoop  Micro tests
- Nanoindentation

Mohs scale

- Mohs scale 1 Tal



- Mohs scale 2 . Gypsum



- Mohs scale 3 Calcite



- Mohs scale 4 Fluorite



Mohs scale

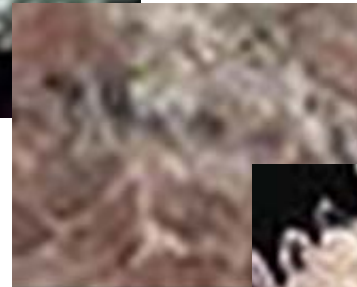
■ Mohs scale 5 Apatite



■ Mohs scale 6 Feldspar

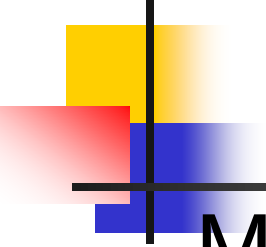


■ Mohs scale 7 Quartz



■ Mohs scale 8 Topaz

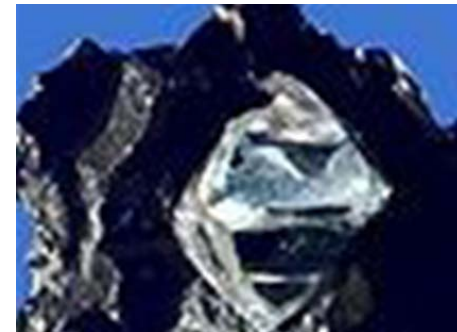




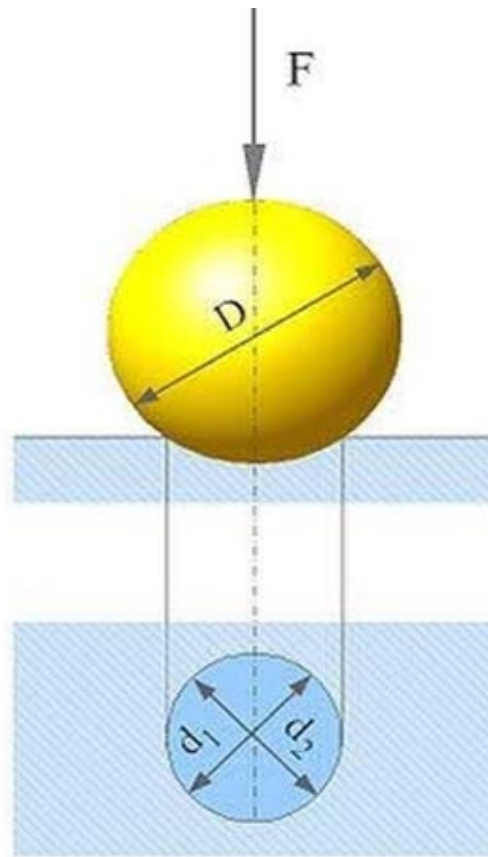
- Mohs scale 9 Corundum



- Mohs scale 10 Diamond



Brinell hardness



- 10 mm dia steel ball

29 kN force (3000 kgf)

Softer - less force .

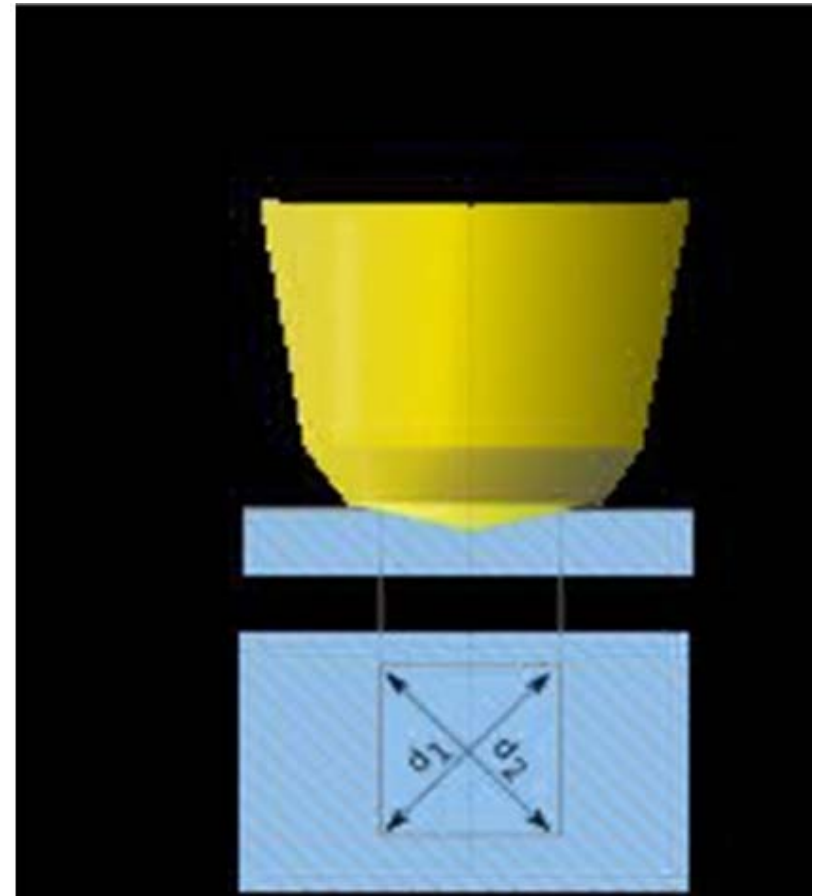
harder -

tungsten carbide ball

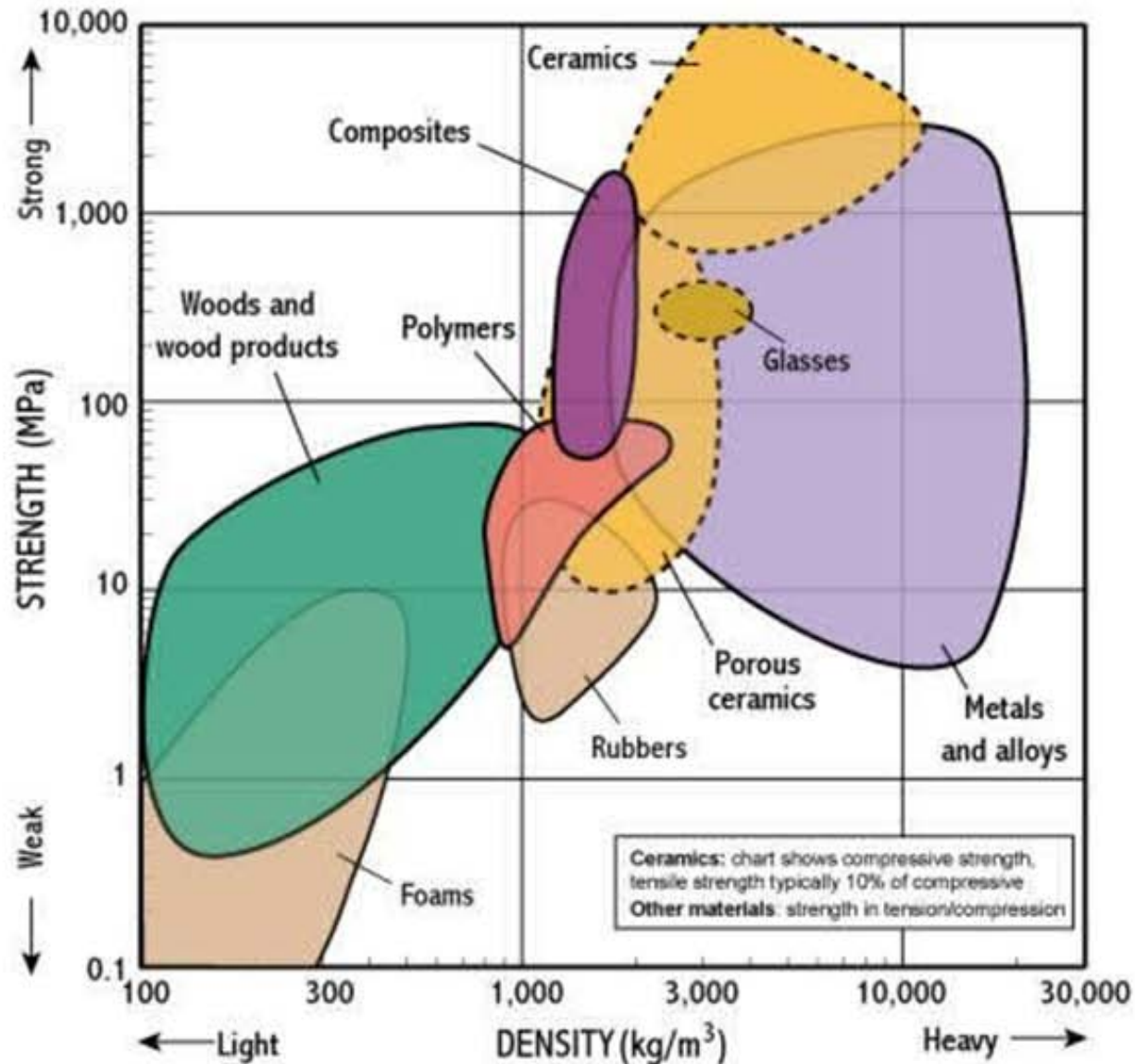
all

Rockwell hardness

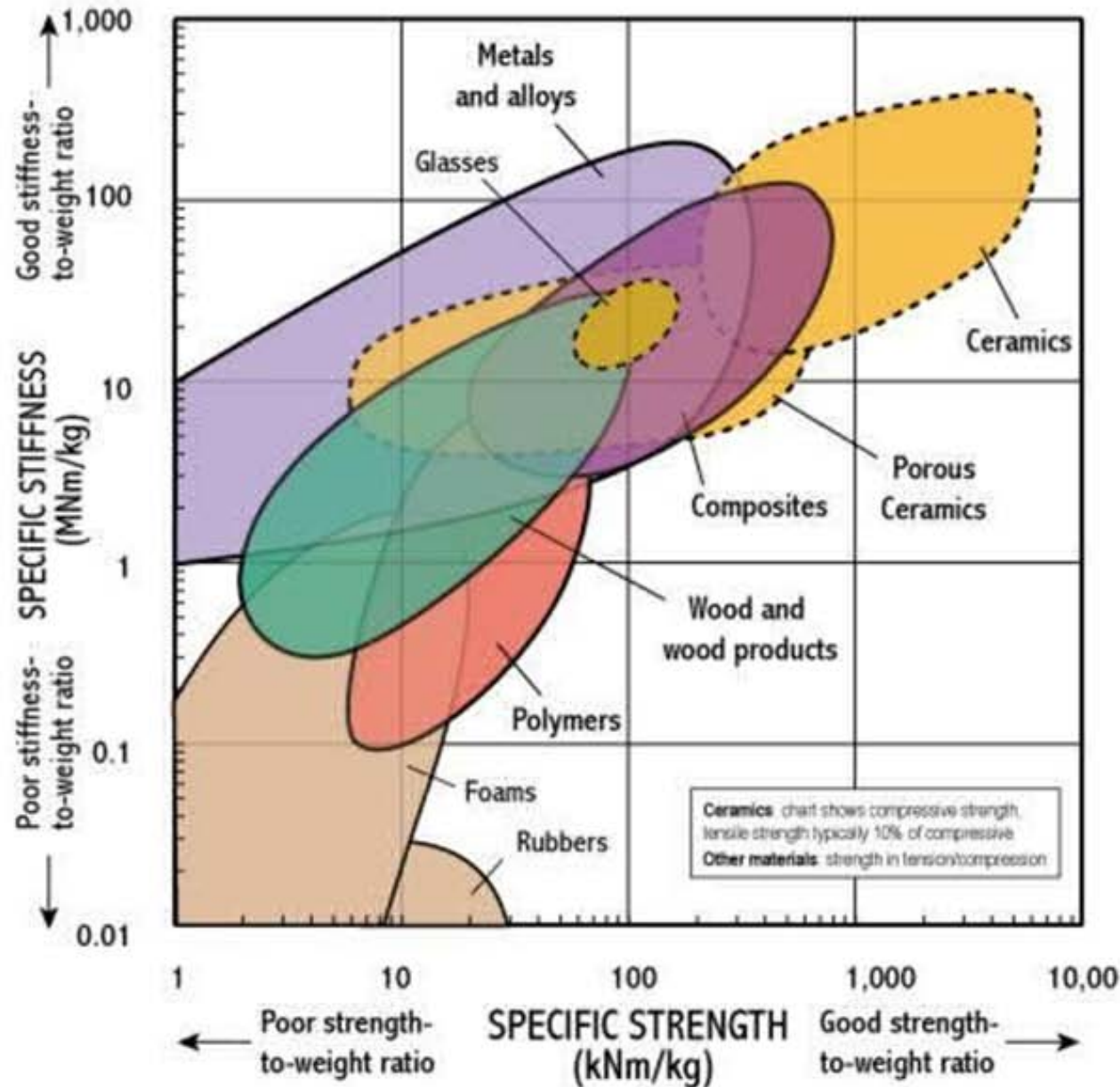
- - Brinell is not truly non-destructive test
 - Rockwell -
 - a minor load and
 - then a major load;
 - note the depth of penetration; read th



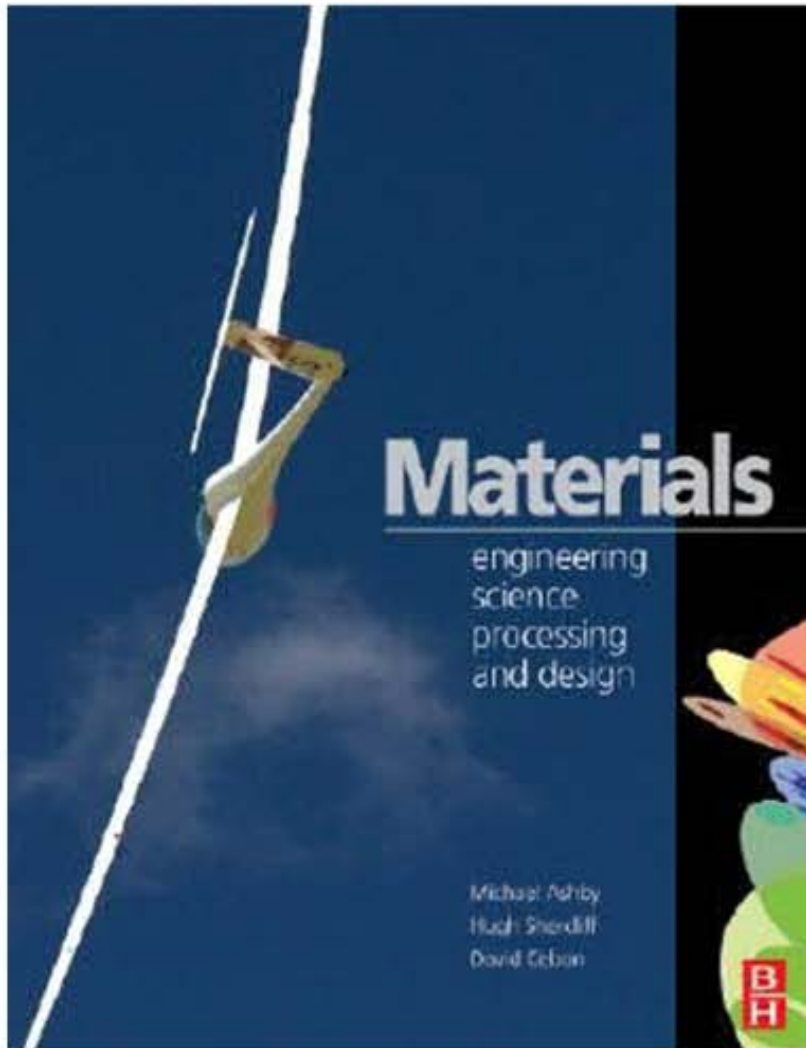
Strength-Density chart



Stiffness—Strength (specific) chart

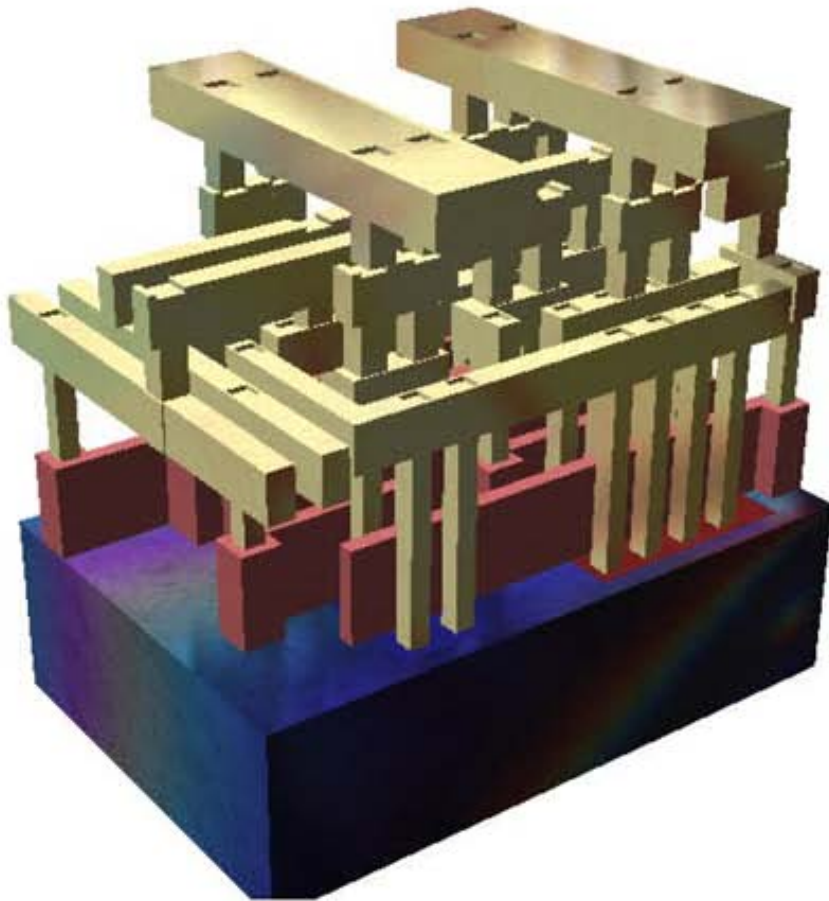


Textbook



- Materials: engineering, science, processing and design,
M F Ashby, H Shercliff and D Cebon,
Butterworth-Heinemann, 2007

A standard cell in a chip

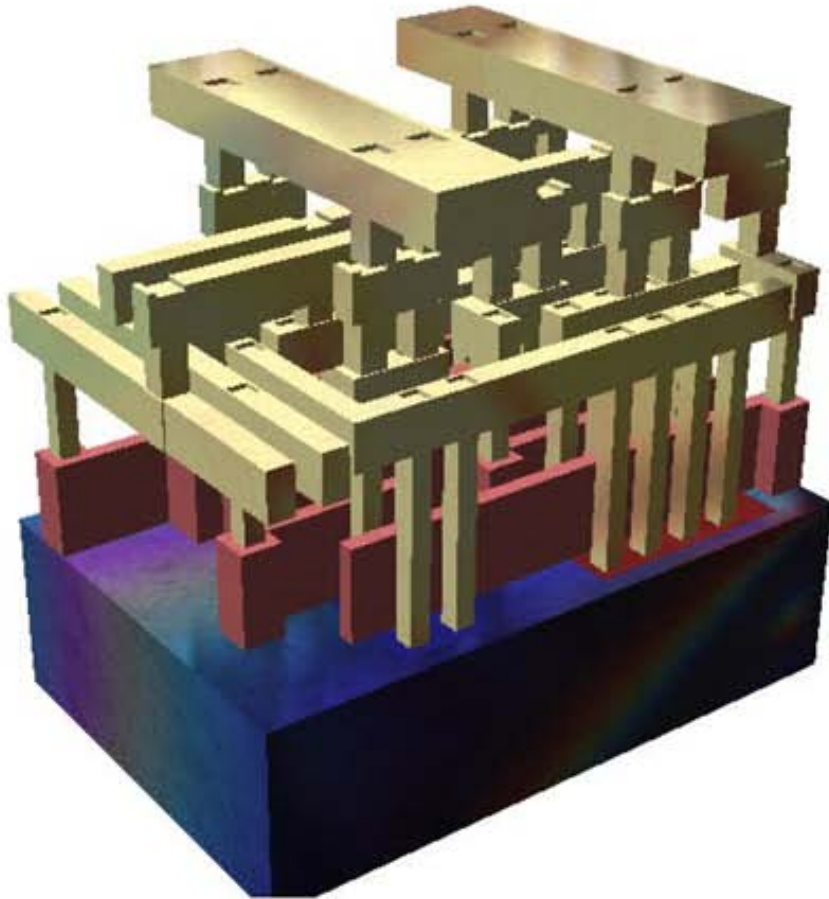


- Rendering of a small standard cell with three metal layers (dielectric has been removed).

The sand-colored structures are metal interconnect, with the vertical pillars being contacts, typically plugs of tungsten. The redish structures are polysilicon gates, and the solid at the bottom is the crystalline silicon bulk.

- Image courtesy: wiki (David Carron)

Types of materials



- Crystalline silicon bulk at the bottom - gives structural support
- Interconnects, contacts, dielectrics and polysilicon gates - have specific functions in terms of electrical conduction or non-conduction