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
To build the structure or fabricate parts

**Simple Object 1**

- Dimensions: 60 x 40 x 30

**Simple Object 2**

- Dimensions: 60 x 40
DEFINING DIMENSIONS

Parallel Dimensions

Super imposed Dimensions

Chain Dimensions

Combined Dimensions

Co ordinate Dimensions
DIMENSIONING FEATURES

Circles

(a) Diameter 100
(b) Diameter 60
(c) Diameter 20

Holes

4 HOLES Ø7 x 10 DEEP

Radii

(a) Radius 5
(b) Radius 15
TOLERENCES

The maximum permissible variation from the dimension

Dimensional Tolerances

Geometric Tolerances

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<tr>
<th>TYPE OF TOLERANCE</th>
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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 (0.30 to ~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)-
**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

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### Key Categories
- **Metals**
- **Non Metals**
- **Metalloids**
- **Gases**

**Alkali metals**: H, Li, Na, K, Rb, Cs, Fr

**Alkaline earths**: Be, Mg, Ca, Sr, Ba

**Lanthinide series**: Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

**Actinide series**: Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr
1. Engineering considerations (Strength, durability..)
2. Cost
3. “Green” ?
4. Easy commercial availability
5. Political (Sanctions on nuclear materials)
6. Technology (Cryogenic engines, ...)
Manufacturing
MANUFACTURING PROCESSES

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

Shell-Making
(Cross-section)

Shell Mold Casting
(Cross-section)

Casting

Clamp
Molten metal
Ladle
Ejector pin
Dump box
Sand-resin mixture
Heated pattern
Shell

Shell mold Casting
Backing material
Flask
Finished casting

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Die-casting

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

- Ladle
- Molten metal
- Motor
- Top rollers
- Mold
- Casting
- Bottom rollers
- Pouring basin
- Finished casting
Investment Casting

Pattern Tree  Shell-Making  Investment Casting  Casting

- Runner
- Sprue
- Wax gating system
- Wax patterns
- Ceramic shell
- Molten metal
- Ladle
- Ceramic slurry
- Hollow ceramic shell
- Finished 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 is performed on a lathe machine.
Definition of a Lathe Machine

- **Bed**
- **Chuck**
- **Tool post**
- **Head stock**
- **Tail stock**

Distance Between Centres

Radius = 1/2 Swing

3-jaw chuck

4-jaw chuck

Feeploeate
Parts of a Lathe Machine
Head Stock
Carriage
Tail Stock

www.machinetoolsupplier.com
A CNC Lathe Machine
Milling

- Milling is a widely-used method for producing slots.

Reaming

Face milling
A SIMPLE MILLING MACHINE

Long Travel

Cross Travel

Vertical Travel (Depth of cut)

Milling machine Motions
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
Shaper machine
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

Diagram of a press break machine:
- Hydraulic Ram
- Back gauge
- Sheet metal
- Punch
- Die
- Bed
Sheet Metal Forming & drawing

Sheet Bending

Deep Drawing

Forming
Welding

Permanently joining metal parts
ARC Welding
Oxy Fuel Welding
Resistance Welding

Brazing & Soldering
LASER PROCESSING
Testing of Materials
Measuring hardness

- Mohs
- Brinell
- Rockwell
- Vickers
- Knoop
- Nanoindentation

- Historical interest
- Macro tests
- Micro tests
Mohs scale

- Mohs scale 1 Talc
- 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

Softer - less force.
Harder - Tungsten carbide ball.
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

- Composites
- Woods and wood products
- Polymers
- Rubbers
- Porous ceramics
- Glasses
- Metals and alloys
- Foams

Ceramics: chart shows compressive strength; tensile strength typically 10% of compressive.
Other materials: strength in tension/compression.
Stiffness—Strength (specific) chart
Textbook

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