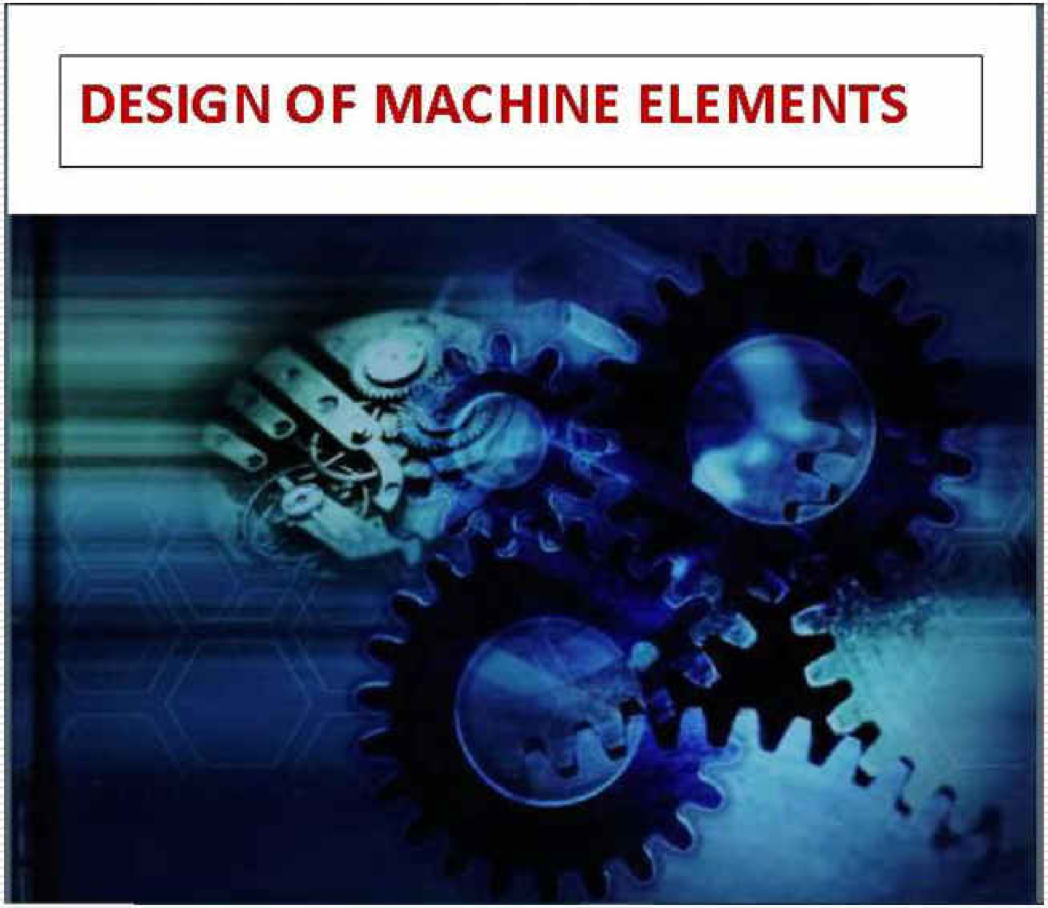
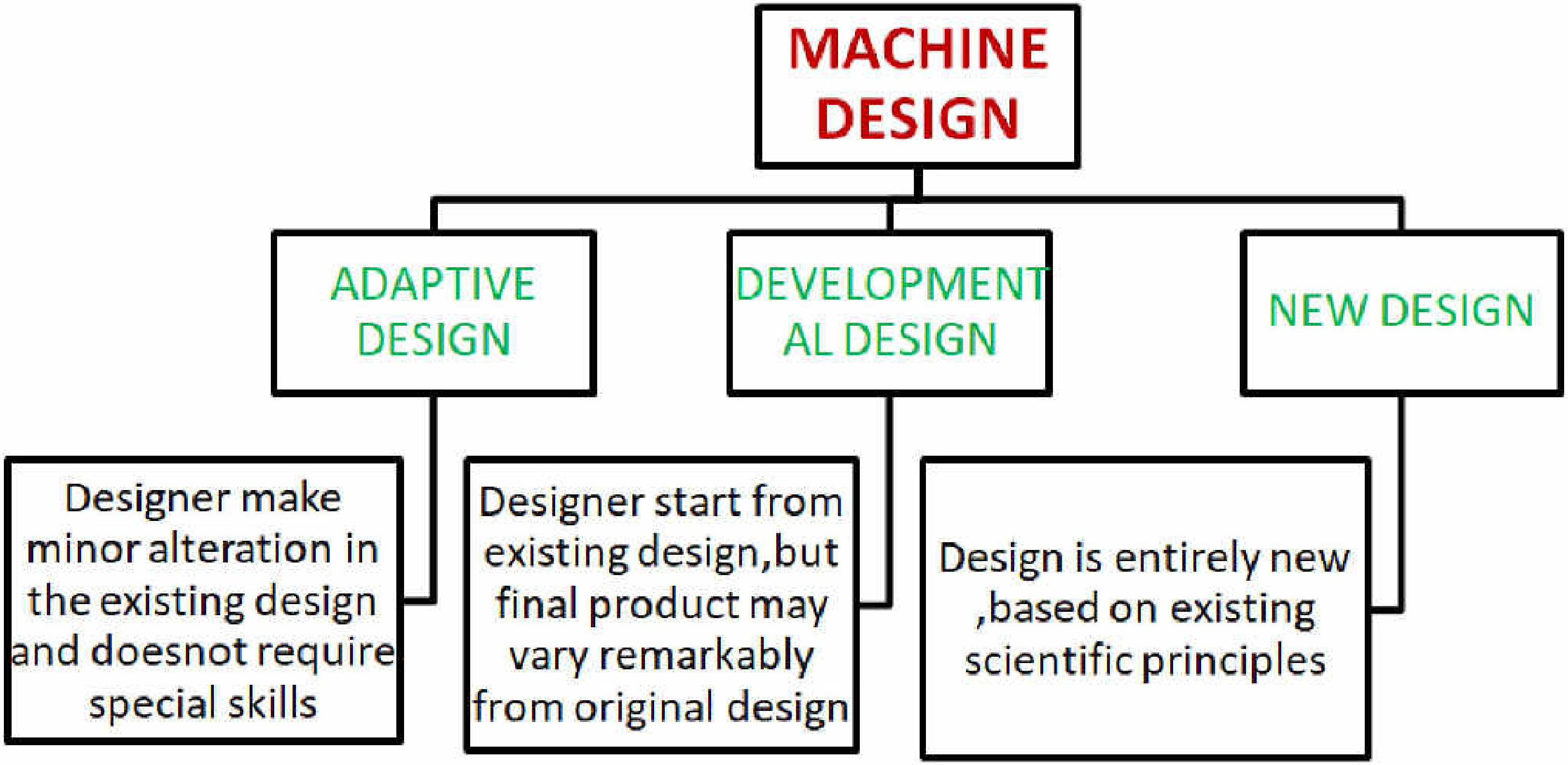
MODULE 1

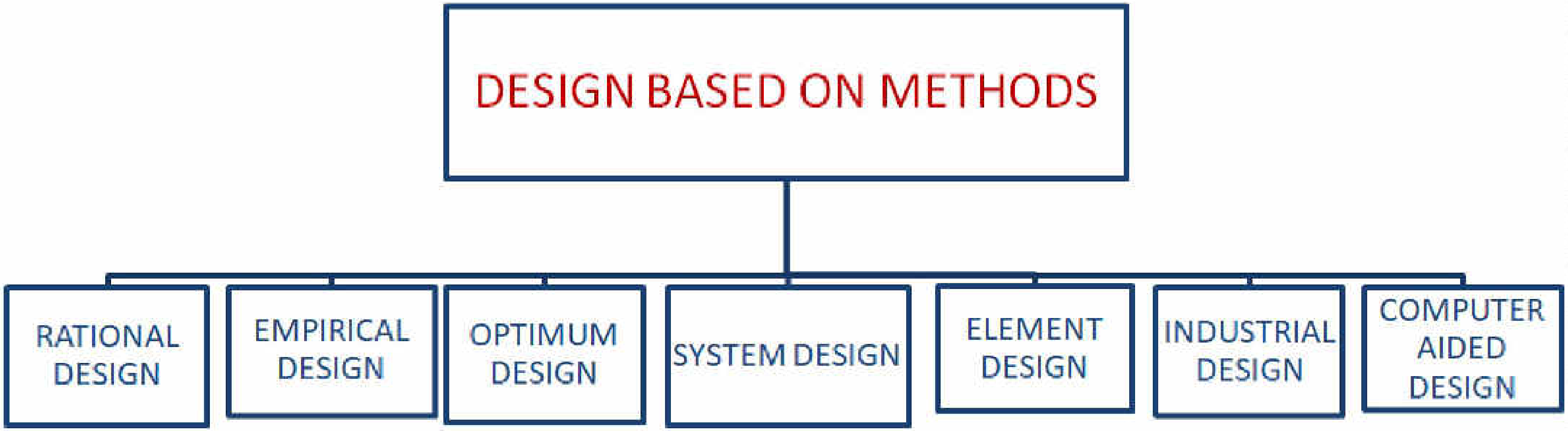
FUNDAMENTALS OF MACHINE DESIGN



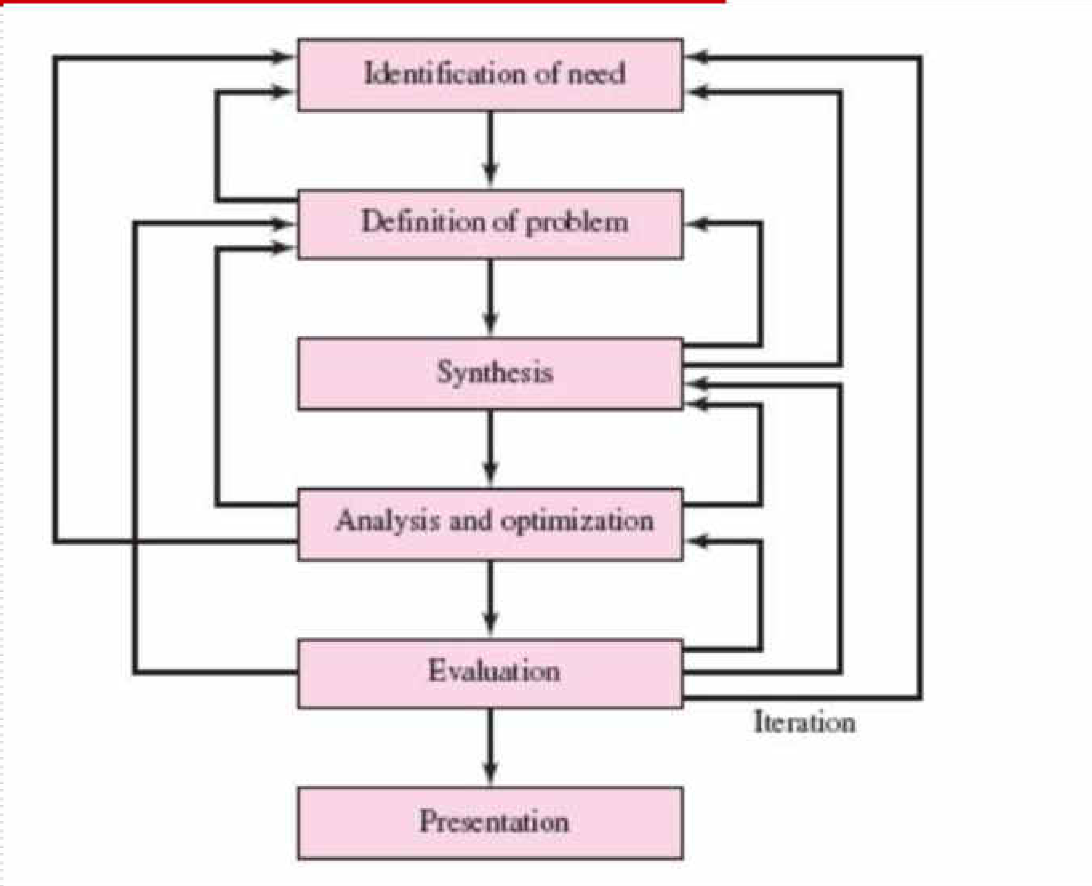
Machine Design is defined as the **use of scientific principles, technical information and imagination in the description of a machine or a mechanical system to perform specific functions with maximum economy and efficiency**.

Design is an iterative process with many interactive phases so as to produce better mechanical system and improve the existing ones.




DESIGN BASED ON METHODS
RATIONAL DESIGN
EMPIRICAL DESIGN
OPTIMUM DESIGN
SYSTEM DESIGN
ELEMENT DESIGN
INDUSTRIAL DESIGN
COMPUTER AIDED DESIGN

PHASES IN DESIGN PROCESS



Identification of need:

Design process begins with the recognition of need, real or imagined, and a decision to do something about it.

Definition of problem:

It includes all the specifications for the product that is to be designed.

The specifications include all forms of input and output quantities related to product, output capacity, cost, expected service life, range, operating temperature and reliability.

(i) Fuel consumption = 40 km/l
(ii) Maximum speed = 85 km/hr
(iii) Carrying capacity = two persons with 10 kg luggage
(iv) Overall dimensions
Width = 700 mm
Length = 1750 mm
Height = 1000 mm
(v) Weight = 95 kg
(vi) Cost = Rs 40000 to Rs 45000

Synthesis:

- It is the phase where we find a solution to the problem.
- It is also called invention of the concept or concept design phase.
- Here designer develops an overall novel idea or concept.

Analysis and Optimization:

- Analysis refers to finding out whether the system satisfies the requirements.
- Optimization refers to the best performance given by the system for which it is designed.
- If the design fails, the synthesis procedure must begin again till optimum performance is achieved.
- The synthesis, analysis and optimization are intimately and iteratively related.

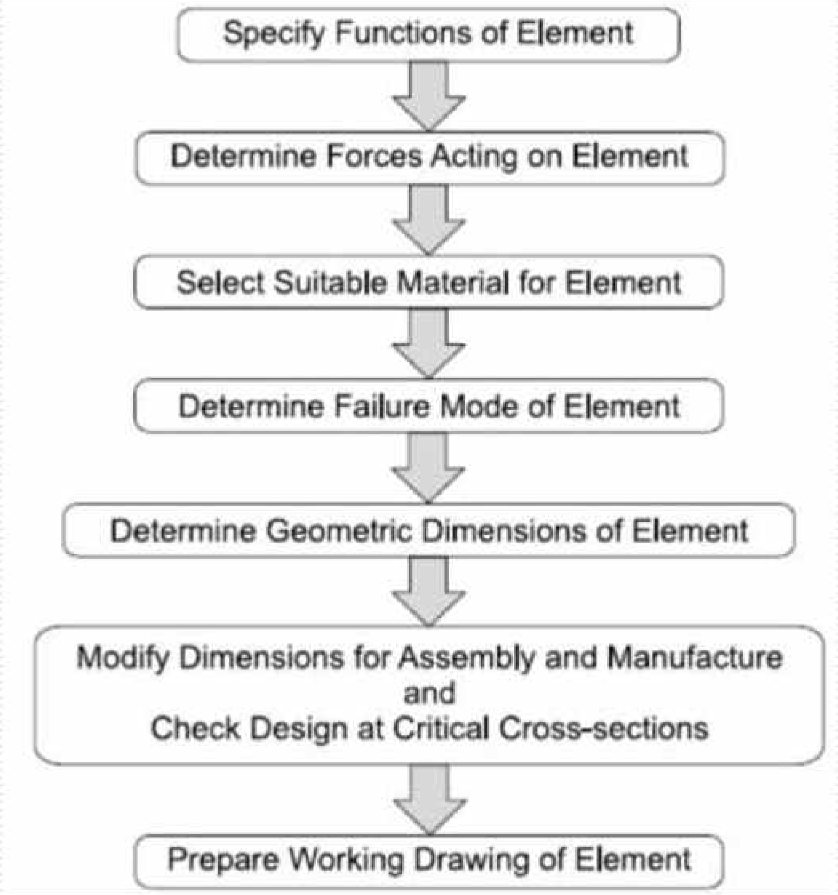
Evaluation:

- This phase is the final proof of a successful design and usually involves the testing of a prototype in the laboratory.
- Here we discover whether the design really satisfies the needs and other desirable features.

Presentation:

- It refers to communicating the design to others.
- It is a selling job. The engineer, when presenting a new solution, attempts to prove that this solution is a better one.

DESIGN OF INDIVIDUAL COMPONENTS



FUNCTIONS,DESIGN REQUIREMENTS AND EVALUATION CRITERIA

- **Functions** tell what the device must do, using general, nonquantitative statements like support a load, transmit power, hold two structural members together.
- **Design Requirements** are quantitative statements of expected performance levels, environmental conditions in which the device must operate, limitations on space or weight, or available materials and components that may be used.
- **Evaluation Criteria** are statements of desirable qualitative characteristics of a design that assists the designer in deciding which alternative design is optimum –that is the design that maximizes benefits while minimizing disadvantages.

DESIGN CONSIDERATIONS

1 Functionality
2 Strength/stress
3 Distortion/deflection/stiffness
4 Wear
5 Corrosion
6 Safety
7 Reliability
8 Manufacturability
9 Utility
10 Cost
11 Friction
12 Weight
13 Life
14 Noise
15 Styling
16 Shape
17 Size
18 Control
19 Thermal properties
20 Surface
21 Lubrication
22 Marketability
23 Maintenance
24 Volume
25 Liability
26 Remanufacturing/resource recovery

EVALUATION CRITERIA

Evaluation Criteria

1. Safety (the relative inherent safety over and above stated requirements)
2. Performance (the degree to which the design concept exceeds requirements)
3. Ease of manufacture
4. Ease of service or replacement of components
5. Ease of operation
6. Low initial cost
7. Low operating and maintenance costs
8. Small size and low weight
9. Low noise and vibration; smooth operation
10. Use of readily available materials and purchased components
11. Prudent use of both uniquely designed parts and commercially available components
12. Appearance that is attractive and appropriate to the application

What is a standard?

- A standard is a set of specifications for parts ,materials, or processes intended to achieve uniformity, efficiency, and a specified quality. One of the important purpose of a standard is to limit the multitude of variations that can arise from the arbitrary creation of a part ,material or process.
- Standards, not having the force of law, are considered voluntary and serve as guidelines. ASME publishes standards and accredits users of standards to ensure that they are capable of manufacturing products that meet those standards.

What is a code?

- A code is a set of specifications for the analysis ,design, manufacture and construction of something.
- The purpose of code is to achieve a specified degree of safety, efficiency and performance or quality.
- A standard is a code when it has been adopted by one or more governmental bodies and is enforceable by law, or when it has been incorporated into a business contract.

STANDARD ORGANISATIONS

American Bearing Manufacturers Association (ABMA)
American Gear Manufacturers Association (AGMA)
American Institute of Steel Construction (AISC)
American Iron and Steel Institute (AISI)
American National Standards Institute (ANSI)
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
American Society of Mechanical Engineers (ASME)
American Society of Testing and Materials (ASTM)
American Welding Society (AWS)
ASM International

British Standards Institution (BSI)
Industrial Fasteners Institute (IFI)
Institute of Transportation Engineers (ITE)
Institution of Mechanical Engineers (IMechE)
International Bureau of Weights and Measures (BIPM)
International Federation of Robotics (IFR)
International Standards Organization (ISO)
National Association of Power Engineers (NAPE)
National Institute for Standards and Technology (NIST)
Society of Automotive Engineers (SAE)
Aluminum Association (AA)

PREFERED SERIES OR NUMBERS

- The number which are used for deciding the range of characteristics of a product.
- The characteristics are power transmitting capacity, load carrying capacity, size of component ,volume etc.
- The preferred number is an important tool which minimises unnecessary variation in sizes .
- It helps to minimise the number of different sizes that need to be manufactured or kept in stock.
- With use of preferred series ,standardised products can be developed

- For deciding the standard range of sizes of product ,we use geometric progression to get preferred number or series.
- There are 5 basic series denoted as series which increases in step of 58%,28%,12%,6% and 3%.
- $R_5, R_{10,}\ R_{20}, R_{40,}\ and\ R_{50}$

Series factors

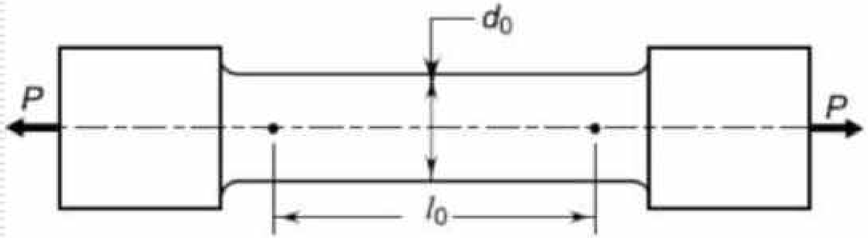
R5 Series	$\sqrt[5]{10} = 1.58$
R10 Series	$\sqrt[10]{10} = 1.26$
R20 Series	$\sqrt[20]{10} = 1.12$
R40 Series	$\sqrt[40]{10} = 1.06$
R80 Series	$\sqrt[80]{10} = 1.03$

The series is established by taking the first number and multiplying it by a series factor to get the second number. The second number is again multiplied by a series factor to get the third number. This procedure is continued until the complete series is built up.

STRESS-STRAIN DIAGRAM

- The following information regarding the behaviour of materials can be obtained from tensile test .

1. Proportional limit
2. Elastic limit
3. Modulus of Elasticity
4. Yield Strength
5. Ultimate tensile Strength
6. Modulus of resilience
7. Modulus of toughness
8. Percentage elongation
9. Percentage reduction in area



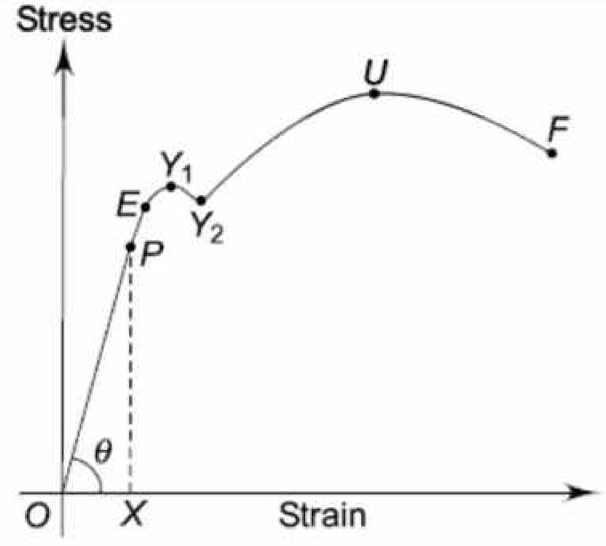
Specimen of Tension-test

STRESS-STRAIN DIAGRAM for ductile materials

Proportional limit is defined as the stress at which the stress strain curve begins to deviate from the straight line. The point P indicates the proportional limit.

Modulus of Elasticity (Young's Modulus; E) is the ratio of stress to strain up to the point P .It is given b y the slope of the line OP.Therefore

$$E = \tan\theta = \frac{PX}{OX} = \frac{\text{stress}}{\text{strain}}$$

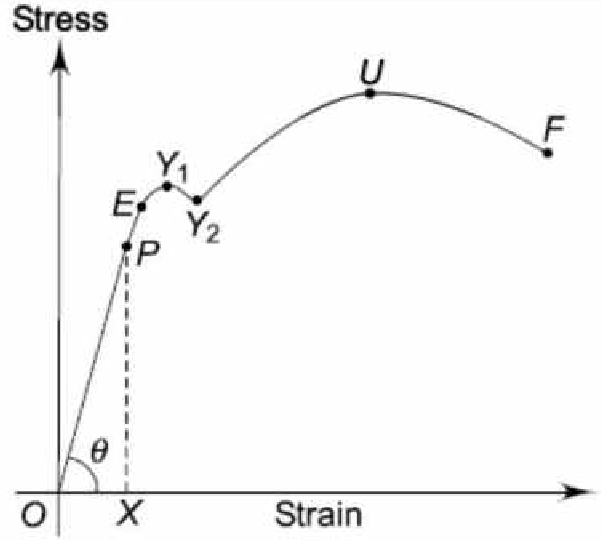


Stress–Strain Diagram of Ductile Materials

STRESS-STRAIN DIAGRAM

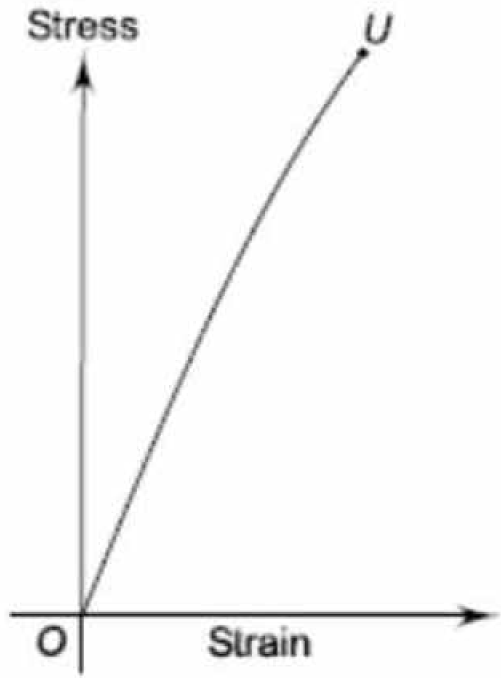
Elastic limit of the material is defined as the maximum stress without any permanent deformation.

Yield strength is defined as the maximum stress at which a marked increase in elongation occurs without increase in the load.



Stress–Strain Diagram of Ductile Materials

Stress –strain diagram for brittle materials



Stress-Strain Diagram of Brittle Materials