FEDERAL UNIVERSITY OYE, OYE-EKITI

DEPARTMENT OF CIVIL ENGINEERING

Strength of Materials – Introduction

1.0 Definition

The strength of a material may be defined as its ability to resist failure or its behaviour under the action of external forces. A material, under the action of force, first deformed then fails afterwards.

A detailed study of forces and their effects along with some suitable protective measures for safe working conditions is known as "strength of materials". The knowledge of strength of materials is very essential for engineers to enable design and maintain all types of structures and machines.

2.0 Some Basics

Fundamental/Derived Quantities (Units)

Fundamental → Length, Mass, Time (m, kg, sec.)

Derived → velocity, acceleration, area, pressure, etc.

Larger multiples of the units

10^{12} → Tera

10^{9} → Giga

10^{6} → Mega

10^{3} → Kilo (grams, meter, etc.)

10^{-3} → Milli

10^{-6} → Micro

10^{-9} → Nano

10^{-12} → Pico

→ An engineer must have a practical appreciation of each of this units

Force

Loads represents the loads that the structure is expected to carry.

Loads that constitutes force can be broadly classified into three viz

- Dead Load →permanent load, e.g. weight of the structure, claddings, finishes, etc.
- Imposed Loads → movable load, e.g. furniture, equipment, occupants, etc.
- Wind Loads → invisible and moving loads.
- Seismic/Impact Loads →

In practice, the structure can be subjected to any combination of these

Forces may be coplanar or non-coplanar

Coplanar Forces → forces that act in same plane

- Concurrent

- Parallel

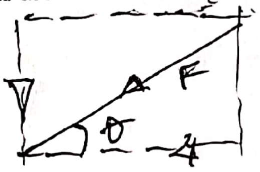
Resultant of Force

The resultant of a given number of forces is the single force which, when substituted for the given forces, has the same effect on the state of equilibrium of the body.

- For 2 forces meeting at a point (triangle or parallelogram of forces)
- For more than 2 forces (polygon of forces)

Component of Force

A given force can be replaced by any two forces (components) which meet at the point of application of the given force. When the angle between the two forces is a right angle, the components are called rectangular components

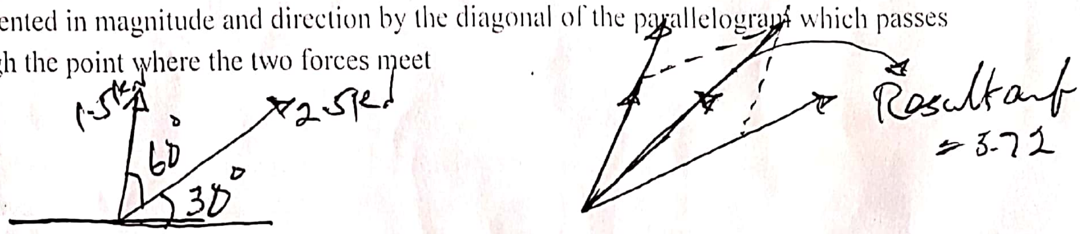


vertical component = F Sinθ

Horizontal component = F Cosθ

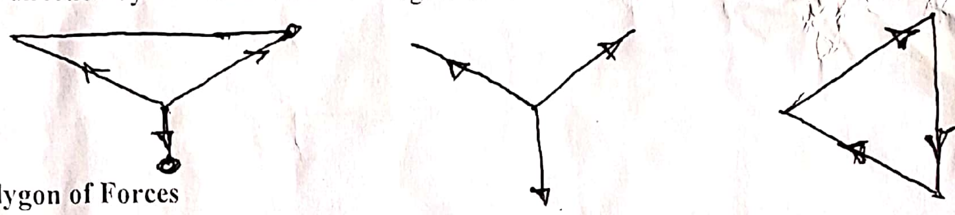
Parallelogram of Forces

If two forces meeting at a point are in equilibrium, they can be represented by the two sides in magnitude and direction by the two sides of a parallelogram, and their resultant is represented in magnitude and direction by the diagonal of the parallelogram which passes through the point where the two forces meet



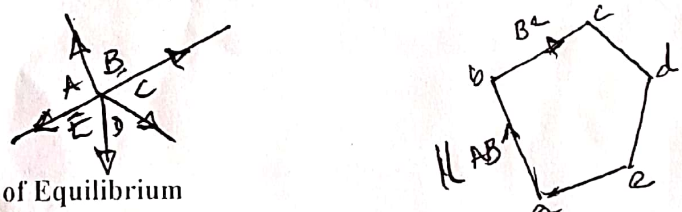
Triangle of Forces

If three forces meeting at a point are in equilibrium, they may be represented in magnitude and direction by the tree sides of a triangle drawn to scale



Polygon of Forces

If any number of forces acting at a point are in equilibrium, then they can be represented in magnitude and direction by the sides of closed polygon taken in order.



Condition of Equilibrium

For a system of forces acting in one plane to be in equilibrium, the three govering laws are:

1. Algebraic sum of all the vertical forces must be zero

$$\sum V = 0$$

2. Algebraic sum of all the horizontal forces must be zero

$$\sum H = 0$$

3. Algebraic sum of the moments of the forces must be zero

$$\sum M = 0$$

Moment of Forces

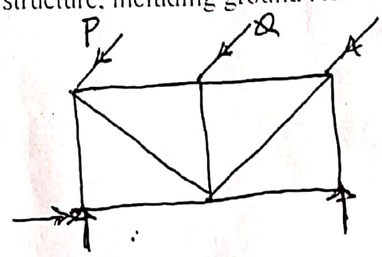
This is a turning effect of a force. It is usually considered in relation to a turning point (real or imaginary).

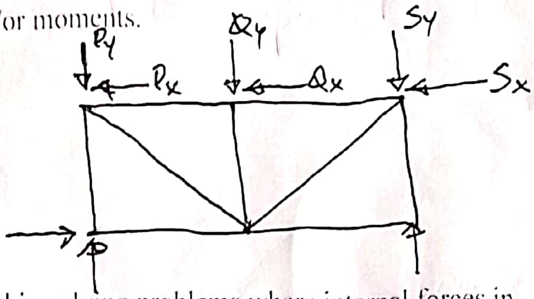
This defined as the product of a force multiplied and a distance, and this distance must be measured from the turning point to where it cuts the line of action of the force at right angles. Simply put, moment is the product of a force and perpendicular distance.

- It is expressed in force-length units such as. N.mm. KN.m. etc.

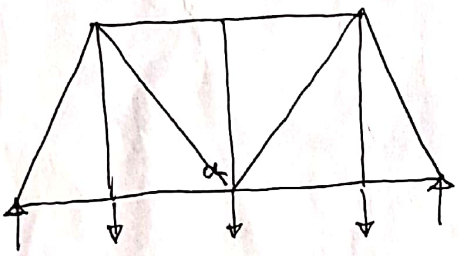
Free Body Diagram

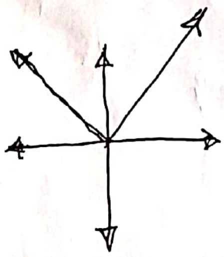
They are a complete diagram or simplified line sketch of the structure (or body), showing the position, direction and point of application of all externally applied forces acting on the structure, including ground reaction forces and/or moments.

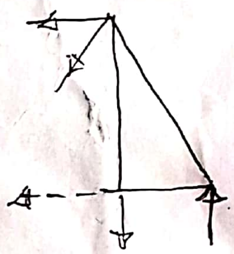




The concept of free body diagram is very useful in solving problems where internal forces in members of a structure are required to be determined. Most free body diagrams are used both to determine the loading of individual structural components as well as calculating internal forces within the structure in almost all the engineering disciplines.







In applying FBD to structure, it is assumed that if a structure as a whole body is in equilibrium, any part of it must also constitute a system of equilibrium bodies. If a portion of it is imagined to be cut free from the whole, this portion will be in equilibrium under the action of any applied loads acting on it.and of the internal forces in the members which are cut.

To find internal forces, the condition of static equilibrium are applied to the free body diagram of the cut member.

The action of forces may manifest itself in any of the following ways.

1 tension
2 Compression
3 Shear
4 Bending
5 Torsion (twisted)