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## MADE EASY

## MECHANICAL ENGINEERING

**Engineering Mechanics**

**BY- Amit Kakkar Sir**

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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# ENGINEERING MECHANICS

"It is a branch of science which deals and predicts the conditions of the system, either at rest or in motion under the action of external forces."

There are two main branches of engineering mechanics they are known as Statics & Dynamics.

**STATICS**

↓

Study of systems which are at REST (No motion)

**DYNAMICS**

↓

Study of systems, which are under motion

↓

**KINEMATICS**

Study of motion without the consideration of the Basic cause of motion i.e. force.

$$\vec{v} = \frac{d\vec{s}}{dt}$$

$$\vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{j} = \frac{d\vec{a}}{dt}$$

} tool used

m, m/s, m/s², m/s³

**KINETICS**

Study of motion with the consideration of the Basic cause of motion i.e. force.

Tool used → N.S. law

$$\vec{F}_{ext} = \frac{d}{dt}(m\vec{v})$$

$$= m \cdot \vec{a}$$

↓

MASS

$\mu \rightarrow \frac{N\text{-}s}{m^2}$ (Pa-s)

$\nu \rightarrow \frac{\mu}{\rho} \Rightarrow m^2/s$

↓

kinematic viscosity

# Engg. Mechanics

## Rigid Body

### Statics

① EM

Diff types of forces
Vectors
NFL of motion
NTL of motion
Equilibrium Concepts
2-forces EQM
3-forces EQM
* Torque
* Principle of Virtual work (POVW)
* Centre of mass and Centroid
* Trusses (SA)

### Dynamics

② EM

* Basic concepts of
* Kinematics and Kinetics
* NSL of motion
* Rectilinear Translation
  - Kinematics
  - Kinetics
* Circular Motion
  - Kinematics
  - Kinetics
* General Motion
  - Rolling → Kinematics Only

## Deformable Body

### Fixed Deformable Body (SOLIDS)

- Statics → SOM
- Dynamics
  - Imp ③ Engg. Mechanics
  - free vibrations with single Degree of freedom system

### Continuous Deformable Body (FLUIDS)

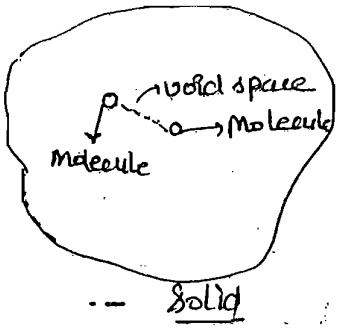
- Statics
- Dynamics

→ Fluid Mechanics

# Idealizations of Concepts in Engg. Mechanics-

1. **Rigid Bodies**- When the load is applied on a body then the body deforms if the deformation in the body is negligible as compared to the dimensions of the body then we can treat these deformations to be zero and the body is said to be a rigid body.
for e.g.- Solids with macroscopic dimensions having very high stiffness [spring constant]

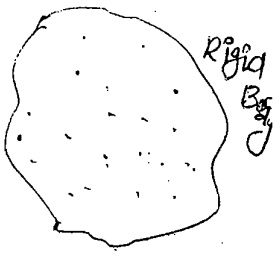
2. **Continuums**-
Even in solids adjacent to one molecule there is a void space because of intermolecular spacing but if the characteristics dimensions of the system are sufficiently good that means then these void spaces which are microscopic can be neglected & we can assume adjacent
Therefore, the matter can be considered as continuous distribution of mass, known as continuum.




3. **Body as a Particles**-

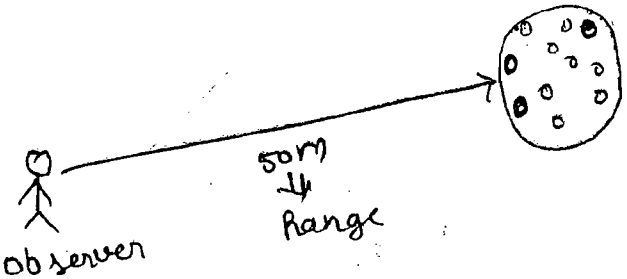
Real → Ideal → Real (point mass)

At every point of the Body → There is a particle




In Reality →
Body is a combination of ∞ number of particles

If size of the Body is very less as Compared to its Range ⇒ Body is treated as a particle




Force ($\vec{F}$) :- "It is action of one body to the other body."

It is a vector Quantity

↓

Having

└→ Magnitude

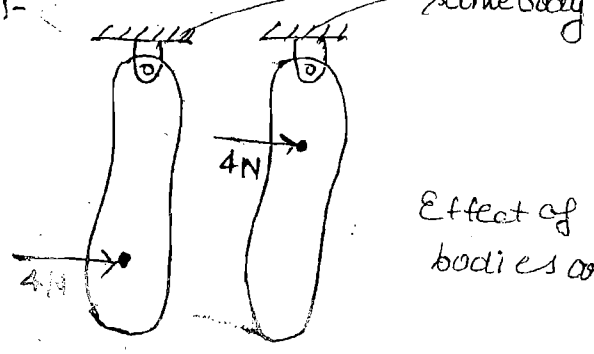
└→ Direction

Unit :- Newton (N)

To define the force acted on the body -

Magnitude
Direction
Point of Application
} are required

for eg :-




Effect of 4 Nt of force on both of bodies are different.

for a force to exist

⇓

Two bodies will be there

One Body → on which force is acted

Other Body → which is applying force

******

Note:-

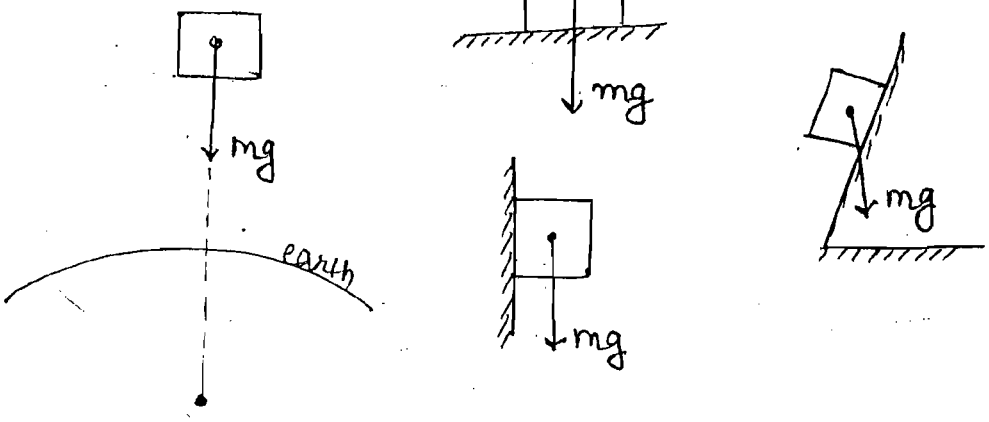
If the force is acted on the Body, but there is no other body which is applying this force, then that force is a PSEUDO FORCE (Artificial force)

## Different Type of forces (most frequently Appearing in EM)-

1. Weight (mg):- It is acted on the body by earth

⇒ It is a Body force and it is in the downward direction.

⇒ It acts at the point on the Body, known as Centre of gravity.

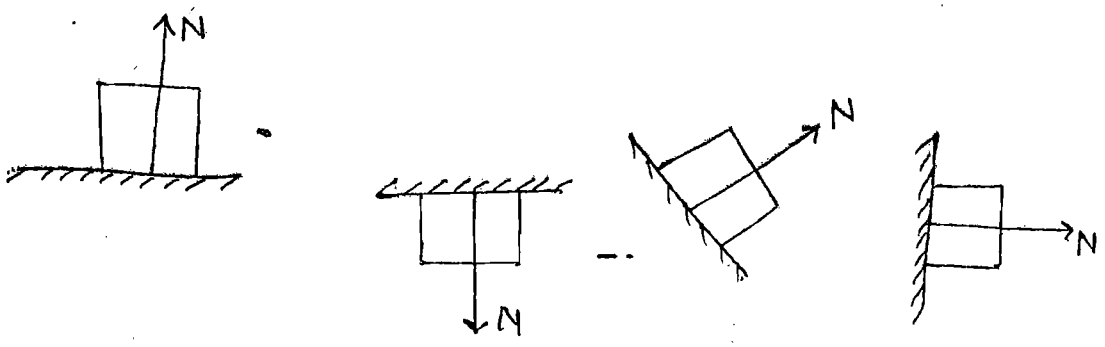



2. Normal Reaction (N):-

It is a surface force

It acts on the Body by the surface, in the direction normal to the surface.

→ It is because of the pressing effect b/w Body and surface.




Note:- If Body is just touching the surface but Not pressing it

$\Rightarrow$ $N = 0$ **

3. ** Frictions- (Dry friction)
(Coulomb friction)

→ It is also a surface force

→ It is along the surface.

→ It resists the relative motion or the tendency of relative motion b/w the contacting surfaces.

friction
- Static friction ($f_s$)
- Kinetic friction ($f_k$)

(1) Static friction ($f_s$):-

→ It is because of the tendency of relative motion b/w the contacting surfaces.
(But there is no relative motion)

→ It is a conservative force

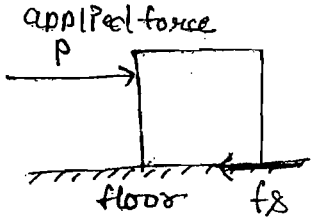
→ It is a variable friction.

$$0 \leq f_s \leq \mu_s N$$

Where -

$\mu_s$ → Coefficient of static friction

N → Normal Reaction between contaction surfaces




| applied force(P) | fs |
|---|---|
| 0 | 0 |
| 1 N | 1 N |
| 2 N | 2 N |
| 3 N | 3 N |
| 4 N | 4 N |
| ⋮ | ⋮ |
| $\mu_s N$ | $\mu_s N$ |

(2) Kinetic friction ($f_K$)-

→ It is because of relative motion between the contacting surface.

$$f_K = \mu_K \cdot N$$

where -

$\mu_K$ → Coefficient of kinetic friction

N → Normal Rxn

→ It is a non-conservation force.

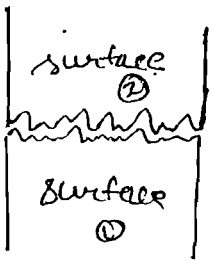
## Coefficient of frictions-

(static, kinetic) ($\mu_s$, $\mu_k$)

→ Its Basic cause is surface Roughness (surface irregularities)

Coefficient of friction depends upon -

1) Surface irregularities
2) How these irregularities interlocks.
3) No. of interlocking



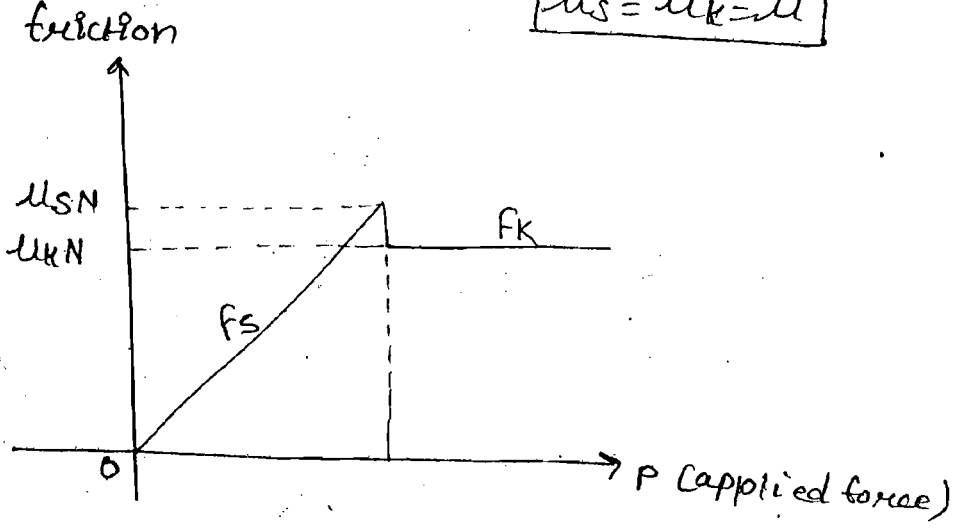

$\mu_s$ is slightly higher than $\mu_k$ -

(Why)??

Because of the slight decrease in the strength of irregularities interlocking, when relative motion starts.

Note:- If only one coefficient of friction is given in the question then take

$$\mu_s = \mu_k = \mu$$




Note:-

Normal Rxn (N) → Surface forces
Friction (f) → Surface forces

The resultant (SOM) of Normal rxn and friction is known as Contact force (R) or Total contact force.

* $\vec{R} = \vec{N} + \vec{F}$