MADE EASY

CIVIL ENGINEERING

ENGINEERING MECHANICS

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

* Engineering Mechanics

→ "It is a science which deals and predicts the condition of the system either at rest or in motion under the action of external force."

Engineering Mechanics

- **Rigid Bodies**
  - **Statics**
    - → Different type of Forces
    - → Vectors
    - → Newtons I & III law (NFL) (NTL)
    - → Equilibrium
    - → Different type of Equlibrium.
    - → Torque
    - → Truss
    - → work
    - → Principle of Virtual work.
    - → Centre of mass and centroid.
  - **Dynamics.**
    - Kinematics
    - Kinetics
      - • Newtons II law of motion (NSL)
      - • Different type of motion.
      - • Rectilinear translation
      - • Circular motion
      - • friction
      - • Rotation
      - • General motion.
- **Deformable bodies**
  - **Solids**
    - Statics
    - Dynamics
      - Kinematics
      - Kinetics
  - **Fluids**
    - Statics
    - Dynamics
      - Kinematics
      - Kinetics

Different ideal concepts in engineering mechanics

1) Rigid body

→ whenever loads applied on body, body deforms but if the deformations are negligible wrt size of the body then we can neglect those deformations and we can treat the bodies as a rigid body.

2) Continuum

→ Even in solids there is void space between the adjucent molecules and atoms we know that these void spaces are microscopic therefor if the size of body is sufficiently good that means microscopic then we can neglect the void spaces and we can assume adjucent to one molecule there is another molecule hence the entire body is treated as continuous distribution of mass known as continuum.

3) Body as a Particles

Body → Real; Particles → Real

Force ($\vec{F}$)

→ Action of one body to the other body.

Vector Quantity

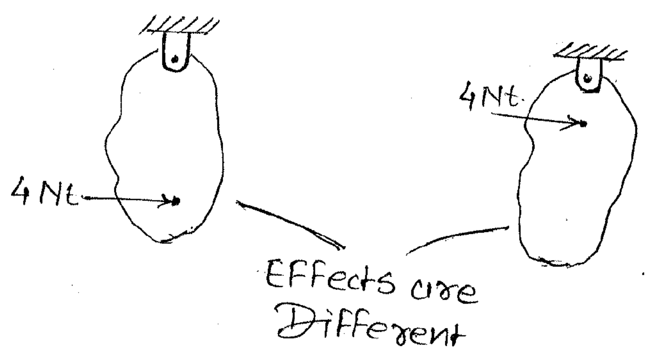
→ Quantities having magnitude and direction.

- when the force is applied on the body this implies that it is applied on some of the particles of body.

Then to define force:

- Magnitude
- Direction
- Point of application

} Required.



whenever the force is applied on the body, then for that force ($\vec{F}$), two bodies will exist.

- → One body → which is applying force
- → Second body → on which the force is applied.

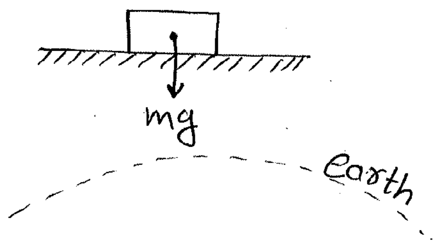
Note

→ If a force is acting on the body, but there is no other body which is applying this force, that force is called Pseudo force (Artificial force)

Different type of forces
[most frequently appearing in EM]

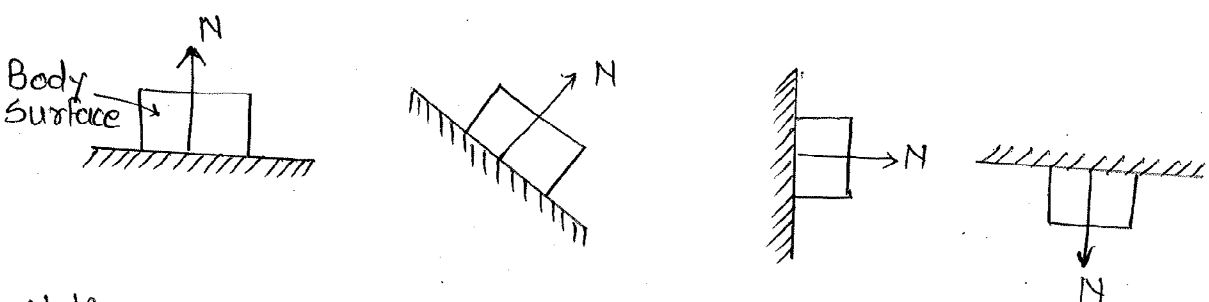
1) Weight (w) (mg)

→ force acted on the body by the earth.
→ It is a body force.



2) Normal Reaction (N) :-

→ Surface force
→ Acts on the body by the surface exactly in the direction perpendicular to the surface.
→ It is due to pressing effect between contacting surface.



Note

→ If the surface are touching but not pressing then,

$\boxed{N = 0}$ **

3) Friction: (Dry Friction)

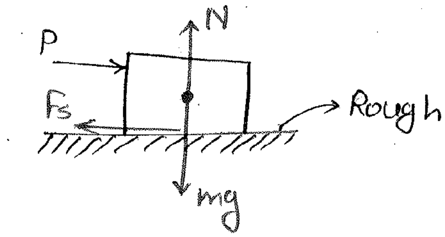
→ Surface force
→ Along the surface
→ It resists the relative motion or tendency or relative motion between the contacting surface.

Static Friction (F_s)

→ Due to the tendency of relative motion between the contacting surface {no relative motion}.

→ It is a variable friction.

$$\boxed{0 \le F_s \le \mu_s N}$$ μ_s → Coefficient of static friction.



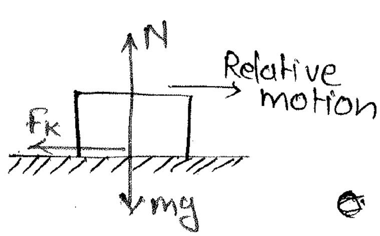
Applied force	Static friction (f_s)
0	0
1 Nt	1 Nt
2 Nt	2 Nt
3 Nt	3 Nt
⋮	⋮
$\mu_s N$	$\mu_s N$

→ Static friction is conservative force

$$\boxed{\text{Energy loss} = 0}$$ **

It is a tendency of relative motion is more than the $F_{s\,max} = \mu_s \cdot N$.

- If relative motion starts friction developed is called kinematic friction (F_K) ~~due~~ this friction is developed due to the relative motion between the contacting surfaces.



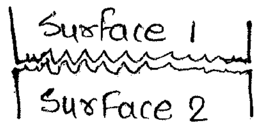
$$\boxed{F_K = \mu_K . N}$$

μ_K → Coeff. of kinetic friction

Constant Friction = Non ~~xxx~~ conservative force
Energy loss.

Coefficient of Friction (μ_s, μ_k)

→ Every surface is having surface irregularities

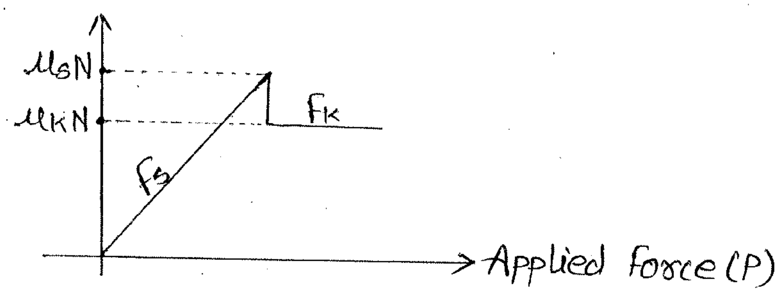


Depends upon

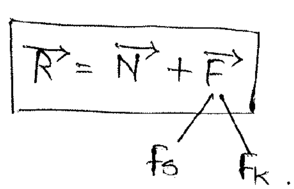
1) Surface irregularities
2) How irregularities are interlocked.
3) No. of interlocking.

"μ_s" is slightly more than "μ_k"

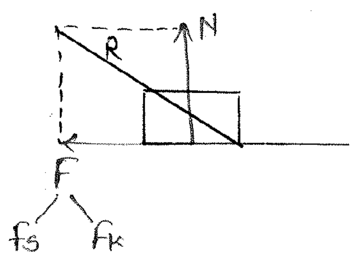
→ Because a little bit decrease in strength of interlocking at the moment when relative motion starts.



Total Contact Force : ($\vec{R}$)

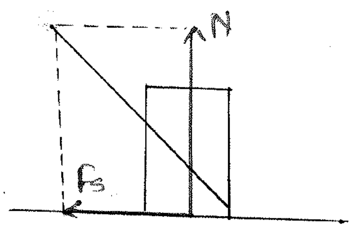


Resultant of friction & normal reaction.



Angle of static friction (ϕ_s)

→ Angle between the normal reaction and total contact forces when body is at verge of Relative motion.

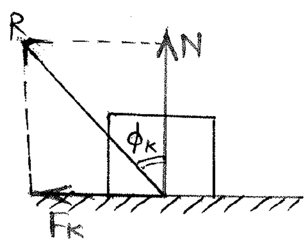


$$\frac{R \sin\phi_s = f_{s\,max} = \mu_s N}{R\cos\phi_s = N}$$

$$\boxed{\mu_s = \tan\phi_s} \;**$$

Angle of kinetic friction (ϕ_K)

→ Angle between normal reaction and total contact force when body is in relative motion.



$$\frac{R\sin\phi_K = f_K = \mu_K N}{R\cos\phi_K = N}$$

$$\boxed{\mu_K = \tan\phi_K} \;**$$

Note • If only one coefficient of friction. (μ)

⇒ $\boxed{\mu_s = \mu_K = \mu}$

• If only one angle of friction (ϕ) is given.

$$\boxed{\mu_s = \mu_K = \tan\phi_s = \tan\phi_K = \tan\phi = \mu}$$

—x—

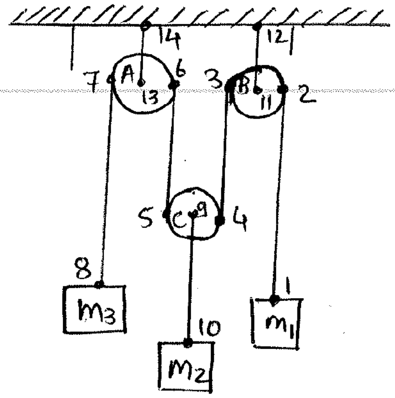
4) Tension (Tension in string):-

→ It is a pulling force.

→ Tension always acts along the string.

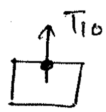
→ It is always away from the body (system).

Consider the following system.

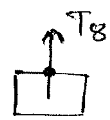


$\underline{m_1}$:

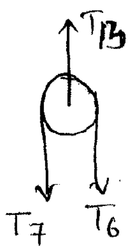
$\underline{m_2}$:



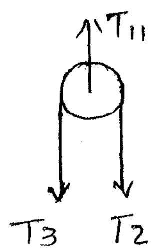
$\underline{m_3}$:



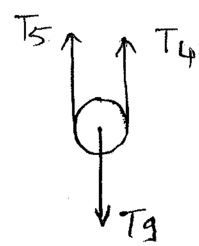
Pulley A:



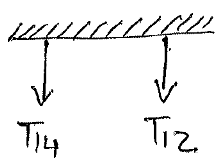
Pulley B:



Pulley C:



Support



1-2 Portion of string