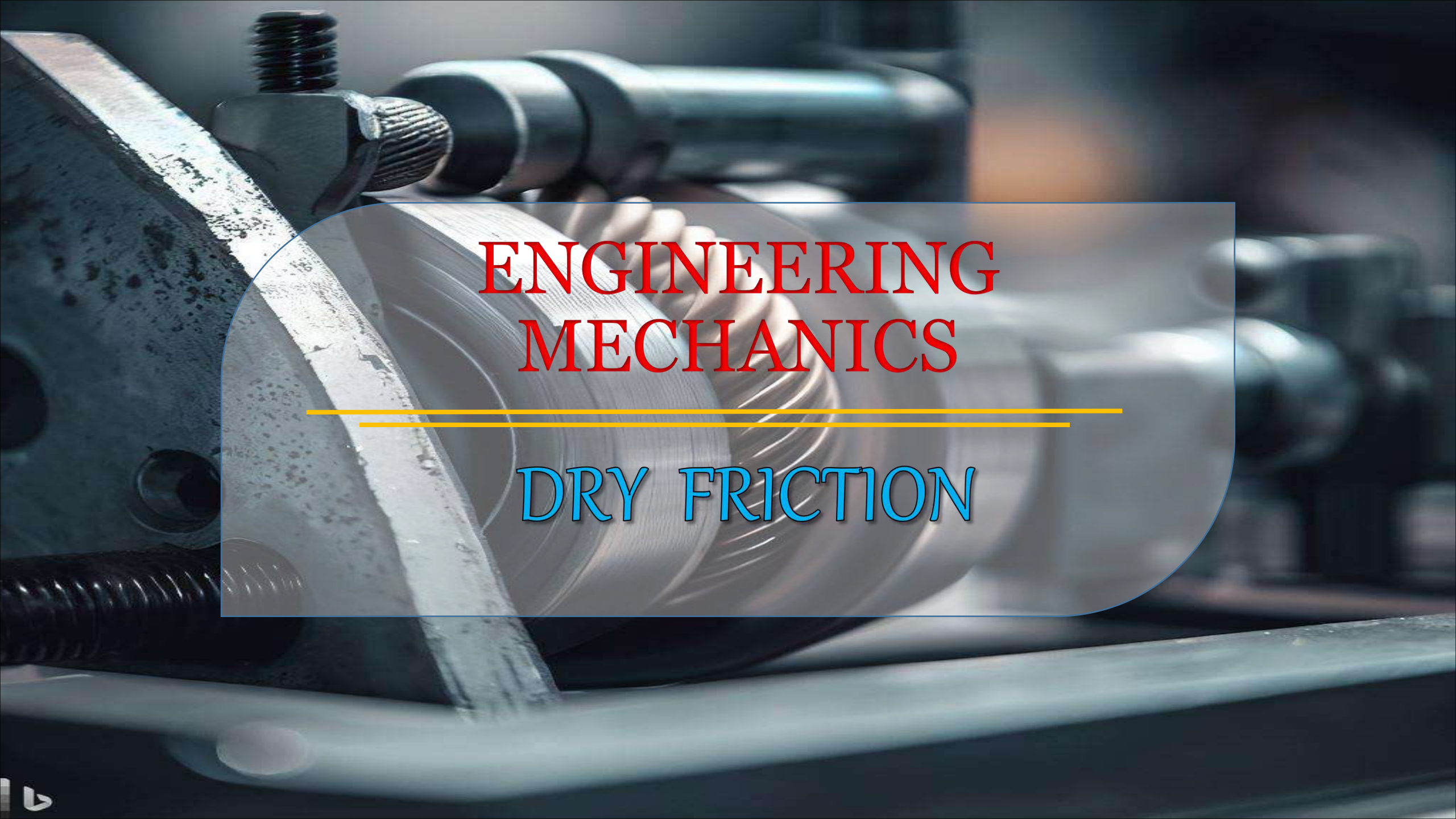

ENGINEERING
MECHANICS
DRY FRICTION

CHARACTERISTICS OF DRY FRICTION

- Friction or retards slipping of the body relative to a second body or surface which it is in contact.
- Acts tangents to the surfaces at point of contact with other body
- Opposing possible or existing motion of the body relatives of points of contact .
- Two types of friction Fluid and Coulomb friction.

CHARACTERISTICS OF DRY FRICTION

- Fluid friction exist when the contacting surface are separated by a film of fluid(gas or liquid)
- Depends on velocity of the fluids and its ability to resist shear force.
- Coulomb friction, is also known as dry friction , occurs between contacting surfaces of bodies in the absence of a lubricating fluid.

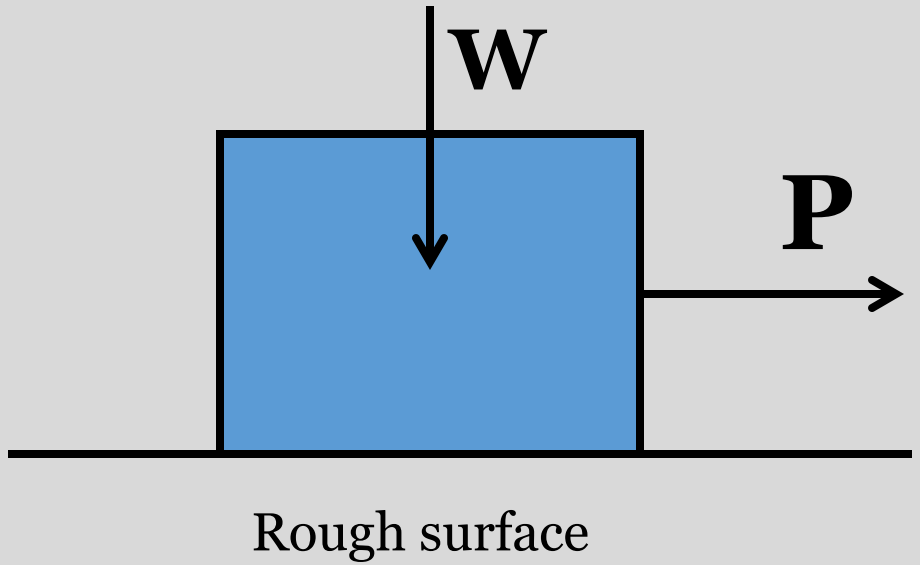
CHARACTERISTICS OF DRY FRICTION

- **Theory of dry friction:-**

➢ Consider the effects caused by pulling horizontally on a block of uniform weight W which is resting on the rough horizontal surface .

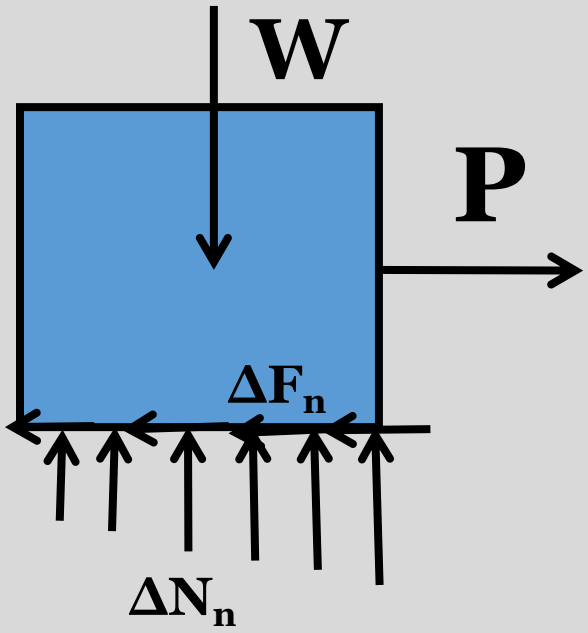
➢ Consider the surface of contact to be nonrigid or deformable and other parts of the block to be rigid.

➢ FBD of the block :-



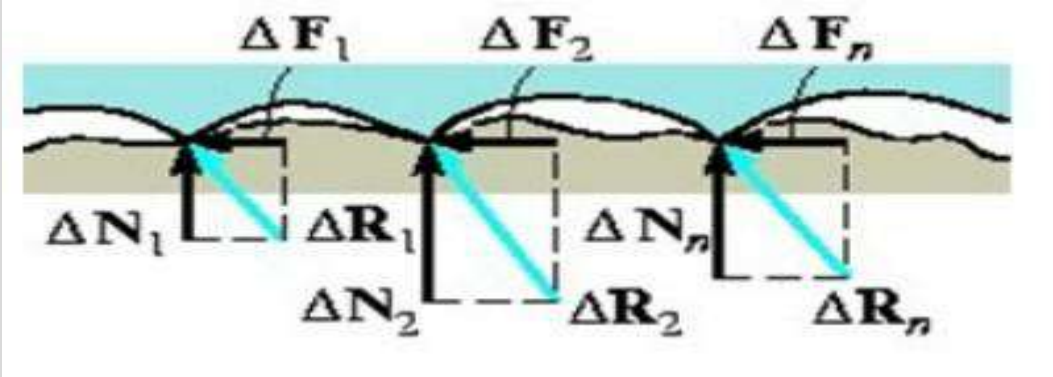
THEORY OF DRY FRICTION

- The floor experts a distribution of the normal force ΔN_n and frictional force ΔF_n along the contact surface.
- For equilibrium , the normal forces act upward to balance the block's weight **W** , and the frictional forces act to the left to prevent force **P** from moving the block to the right.



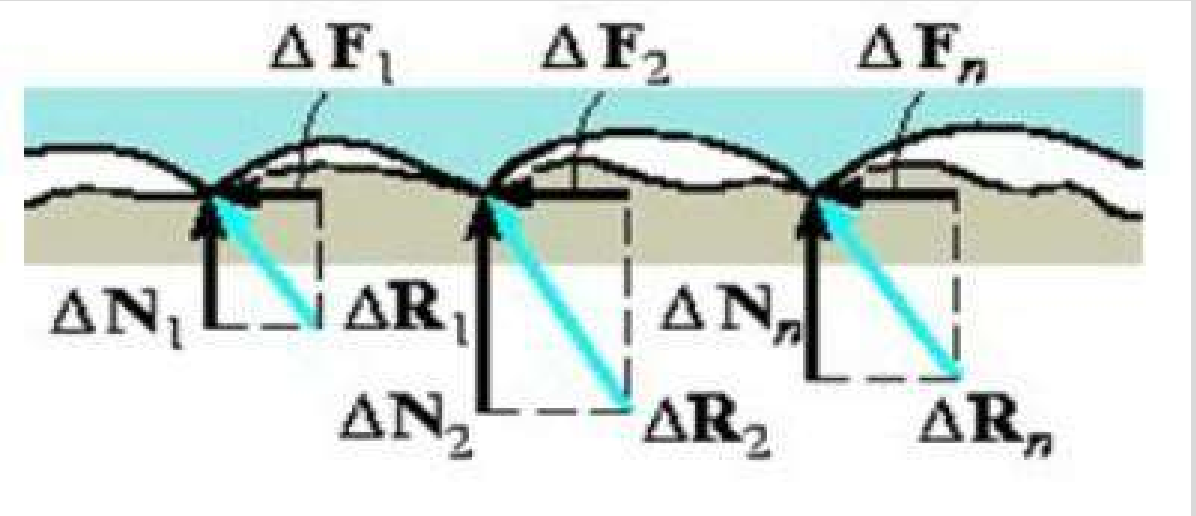
THEORY OF DRY FRICTION

- Examining the contacting surfaces between the floor and the block , it can see that many microsropic irregularities exist between the two surfaces.
- Reactive forces ΔR_n developed at each of the protuberances.



THEORY OF DRY FRICTION

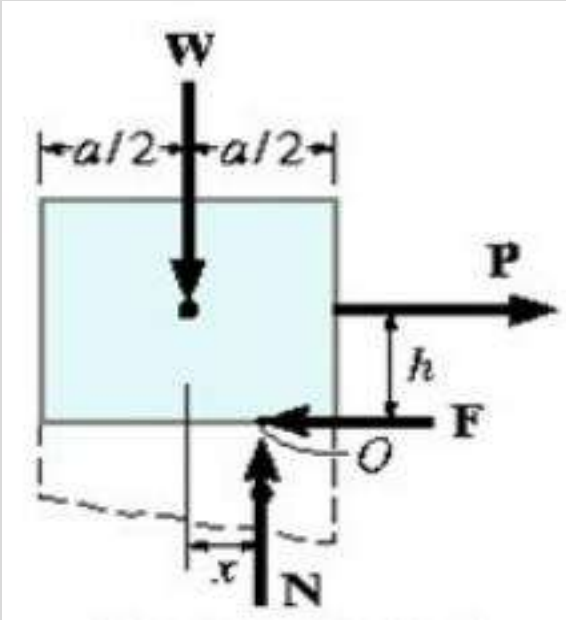
- These forces act at all points of contact and each reactive force consist of both a frictional component ΔF_n and a normal componenet ΔN_n .



THEORY OF DRY FRICTION

❑Equilibrium :-

- ➢Effect of normal and frictional loadings are indicating by their resultant N and F.
- ➢Dristribution of ΔF_n indicates that F is tangent to the contacting surface , opposite to the direction of **P**.
- ➢Normal force N is determined from the distribution of ΔN_n

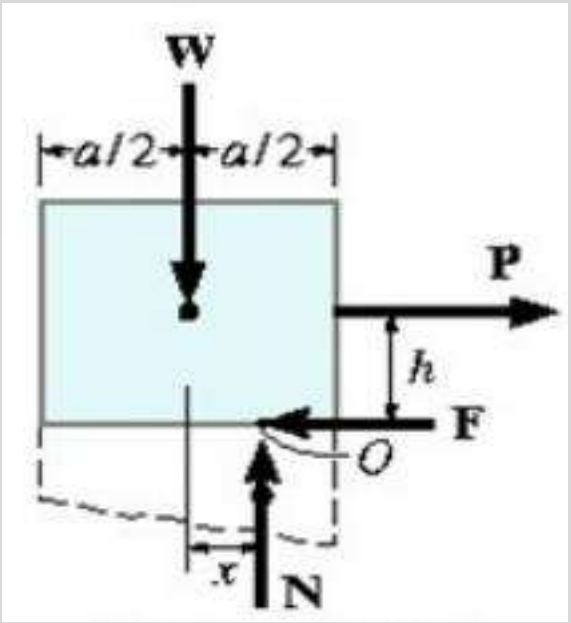


Resultant force and normal forces

THEORY OF DRY FRICTION

❑Example:-

- P is applied at a height h from the surface
- Moment equilibrium about point O is satisfied if $X = Ph/W$
- The block is on the verge on tipping if N acts at the right corner of the block $X = a/2$



Resultant force and normal forces

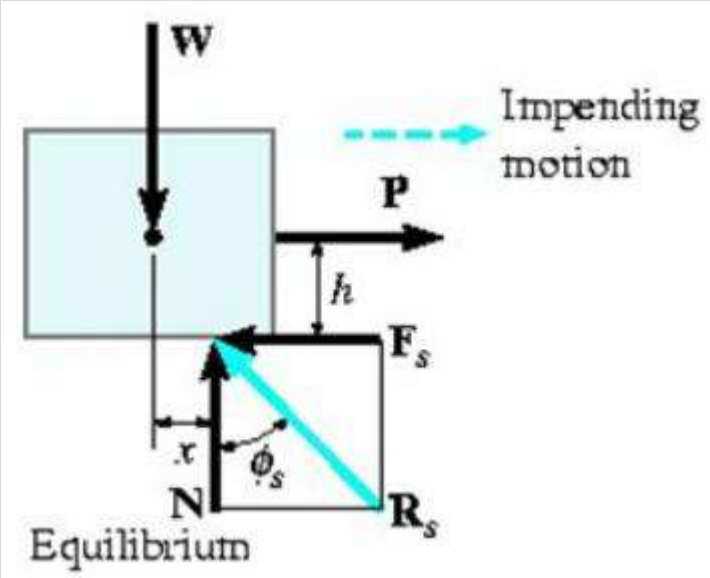
THEORY OF DRY FRICTION

- Impending motion:-
  - In cases h is small or surfaces of contact are rather "slippery" ,the frictional force F may not be great enough to balance P and consequently , the block will tend to slip before it can tip.
  - As P is slowly increased , F correspondingly increase untill it attains a certain maximum value F , called the limiting static force.

THEORY OF DRY FRICTION

- When the value is reached , any further increase in P will cause deformation and fractures at the points of surface contact and consequently , the block will begin to move .
- Limiting static frictional force F_s is directly proportional to resultant normal force N

$$F_s = \mu_s N$$



THEORY OF DRY FRICTION

- Constant of proportionlity μ_s is known as the coefficient of static friction .
- When the block is on the verge of sliding , the normal force N and the frictional force F_s combine to form a resultant R_s .
- Angel $\emptyset_s$ that R_s makes with N is called the angle of static friction.

$$\emptyset_s = \tan^{-1}\left(\frac{F_s}{N}\right) = \tan^{-1}\left(\frac{\mu_s N}{N}\right) = \tan^{-1}\mu_s$$

THEORY OF DRY FRICTION

➢ Typical values of μ_s

Contact metarials	Coefficient of static friction
Metal on ice	0.03 - 0.05
Wood on wood	0.3 - 0.7
Leather on wood	0.2 - 0.5
Leather on metal	0.3 - 0.6
Aluminium on aluminium	1.1 - 1`.7

THEORY OF DRY FRICTION

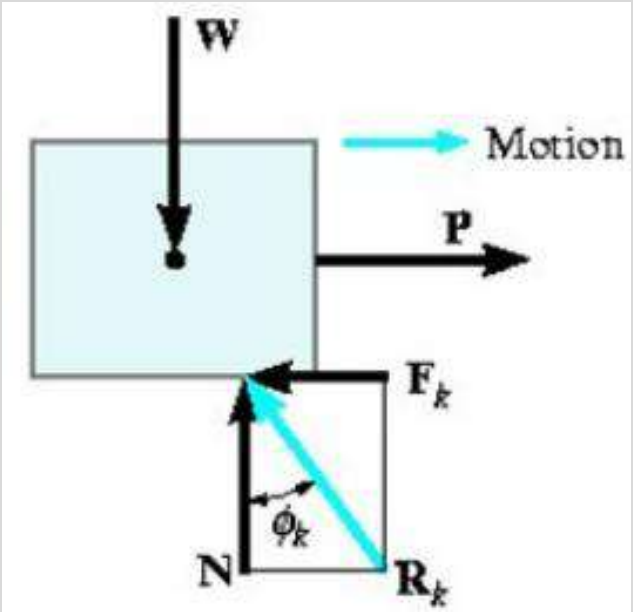
❑ **Tabular values of μ_s : —**

- Coefficient usually < 1 but for aluminium on aluminium , coefficient > 1 .
- For coefficient > 1 , frictional force > normal force
- μ_s is dimensionless and depends on the characteristics of the contacting surfaces .
- When a more accurate calculation of F_s is needed , coefficient of friction is determined by experiments of the two metarials involved.

THEORY OF DRY FRICTION

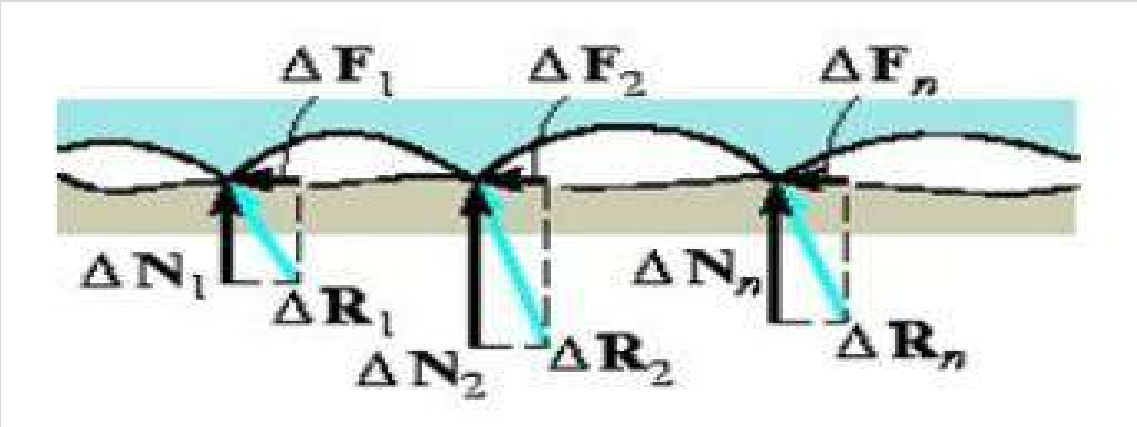
❑Motion:-

- If the magnitude of P acting on the block is increased so that it is greater than F_s , the frictional force at the contacting surfaces drops slightly to a smaller value F_s , called kinetic frictional force.
- The block will not be held in equilibrium ($P > F_s$)but slide with increasing speed.



THEORY OF DRY FRICTION

- The drop made in the frictional force magnitude from F_s (static) to F_k (kinetic) , can explained by examining the contacting surfaces.
- When $P > F_s$, P has the capacity to shear off the peaks at the contact surfaces , causing the blocks to lift and ride on top of these peaks.



THEORY OF DRY FRICTION

- Once the block begins to slide , high local temparatures at these points of contact cause momentary adhesion (welding) of these points .
- Continued shearing of these welds is the dominate mechanism causing friction.
- Since resultant forces ΔR_n are aligned more in the vertical direction than before , they contribute smaller frictional components ΔF_n than when the irregularities are meshed.

THEORY OF DRY FRICTION

- Resultant frictional force F_k is directly proportional to the magnitude of the resultant normal force N.

$$F_k = \mu_k N$$

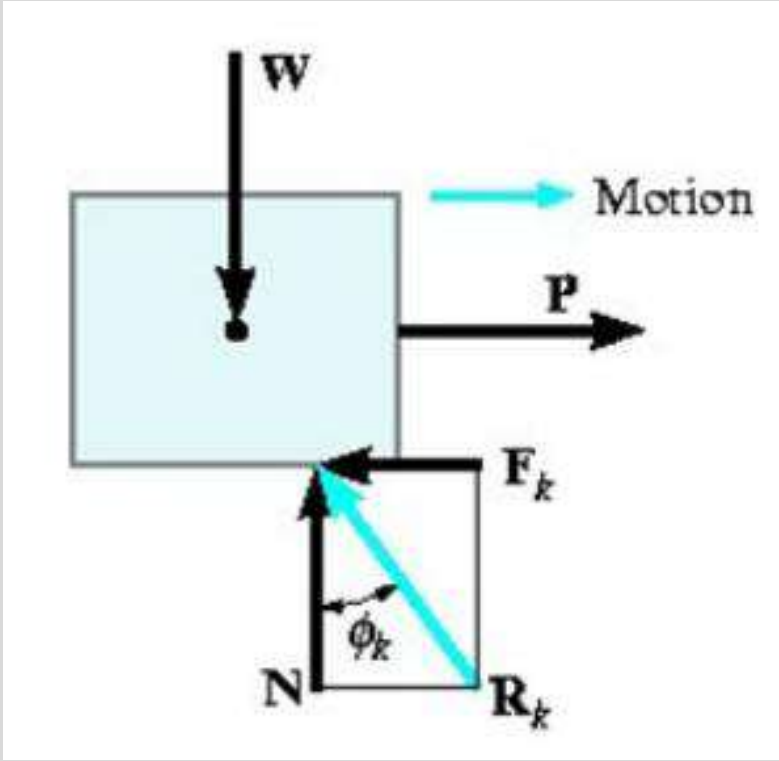
- Constant of proportionality μ_k is called the coefficient of kinetic friction .
- μ_k are typically 25% smaller than μ_s .

THEORY OF DRY FRICTION

- Resultant R_k has a line of action defined by $\emptyset_k$, angle of kinetic friction

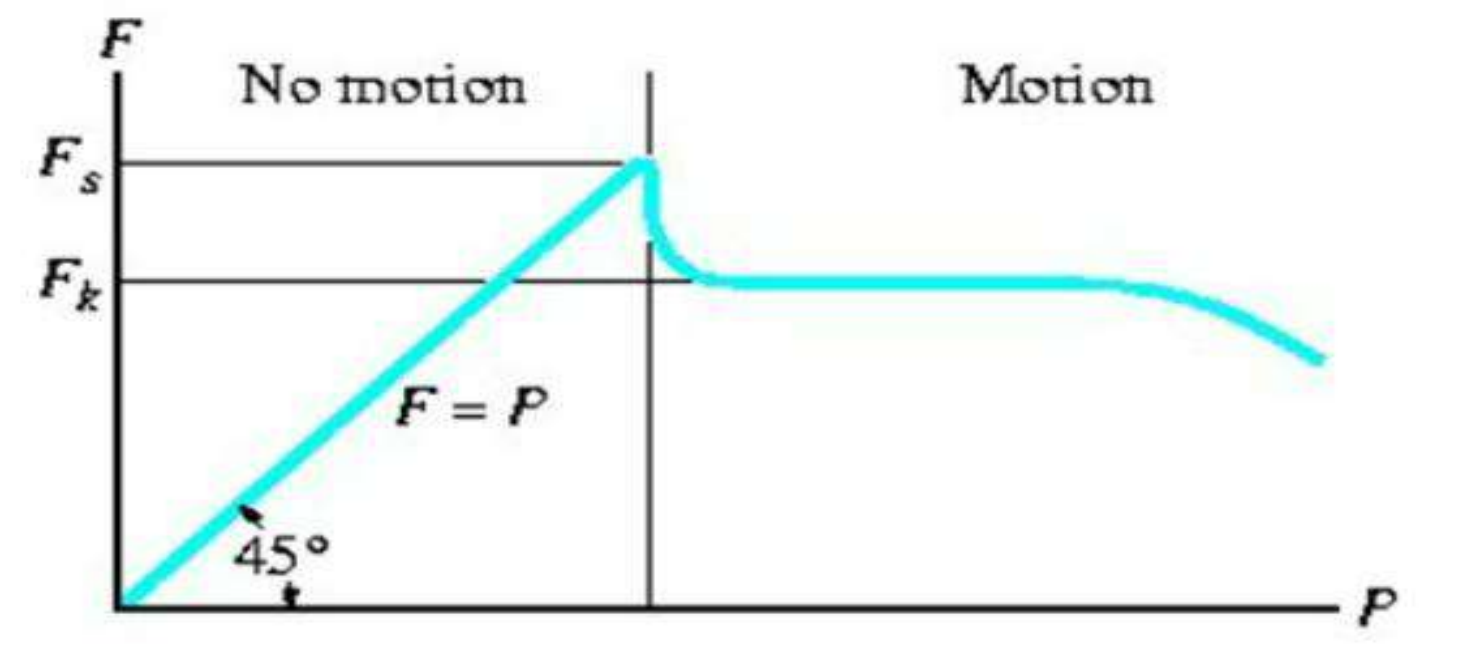
$$\emptyset_k = \tan^{-1}\left(\frac{F_k}{N}\right) = \tan^{-1}\left(\mu_k\right)$$

- $\emptyset_k <= \emptyset_s$



THEORY OF DRY FRICTION

- The graph summarizes the effects regarding friction and shows the variation of frictional force F versus applied load P



THEORY OF DRY FRICTION

- Frictional force is categorized into three ways

I. F is a static frictional force if equilibrium is maintained .

II. F is a limiting static frictional force F_s when it reaches the maximum value needed to maintain equilibrium

III. F is a kinetic-frictional force F_k when when sliding occurs at the contact surface

THEORY OF DRY FRICTION

- The frictional force acts tangent to the contacting surfaces in a direction opposite to the relative motion or tendency for motion of one surface against another.
- The maximum frictional force F_s that can be developed is independent of the area of contact , provided the normal pressures is not very low or great enough to severely deform of crush the contacting surfaces of the bodies .

CHARACTERISTICS OF DRY FRICTION

- The maximum static frictional force is generally greater than the kinetic frictional force.
- However, if one of the bodies is moving with a very slow velocity over the surface of another ,F_k becomes approximately equal to F_s.
- When slipping at the surface of contact is about to occur , the maximum static frictional force is proportional to the normal force.

THANK YOU SIR

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