DEPARTMENT OF MECHANICAL ENGINEERING

PARALA MAHARAJA ENGINEERING COLLEGE, SITALAPALLI, BERHAMPUR

ENGINEERING MECHANICS

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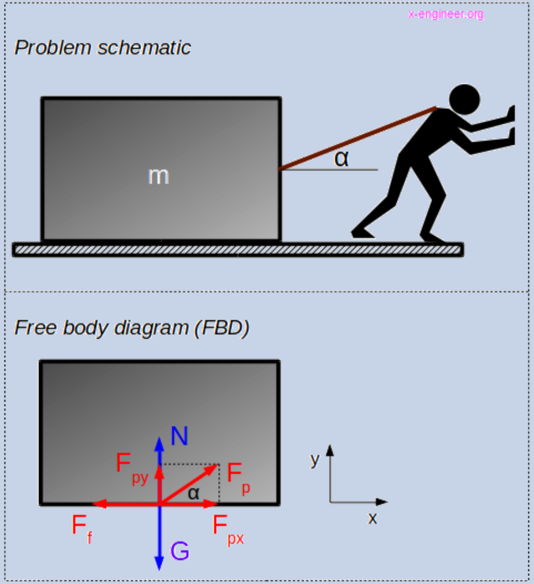
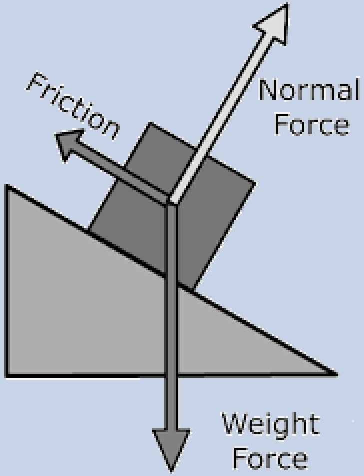
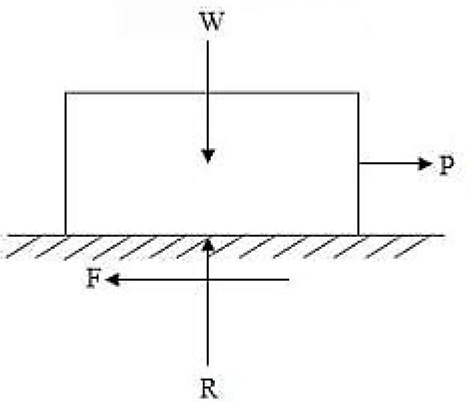






Chapter-Friction

Let's Begin

“*When a body moves or tends to move over another body, aforce opposing the motion develops at contact surface .This force oppose the movement or tendancy to move ,it’s called Frictional force or Friction*

Cause of Friction

- Friction is due to minutely projecting particles on the contact surface.
- Friction force has a property of adjusting itself in magnitude to the force producing motion or (tends to produce motion), so that motion is prevented.
- But it does have a limitation though.

Limiting Friction(f_l)

The maximum value of friction force that can be developed at the contact surface when the body is just on the point of movement is called limiting friction.

Classification of Friction

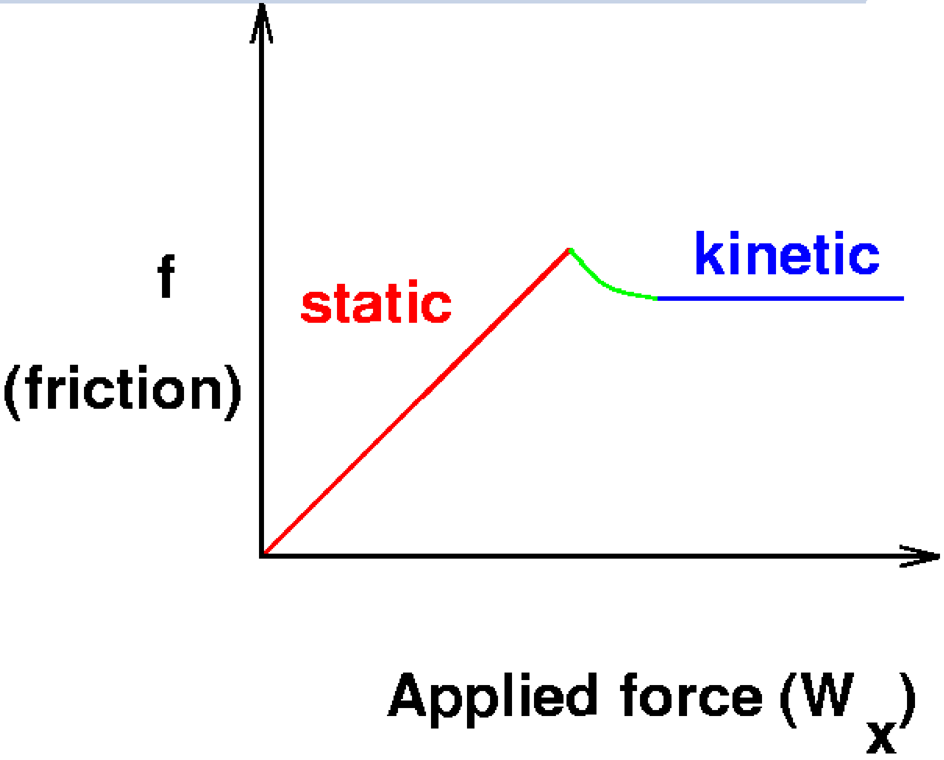
Static Friction

When applied load is less than limiting friction body will remain at rest ,such friction is known as Static Friction.

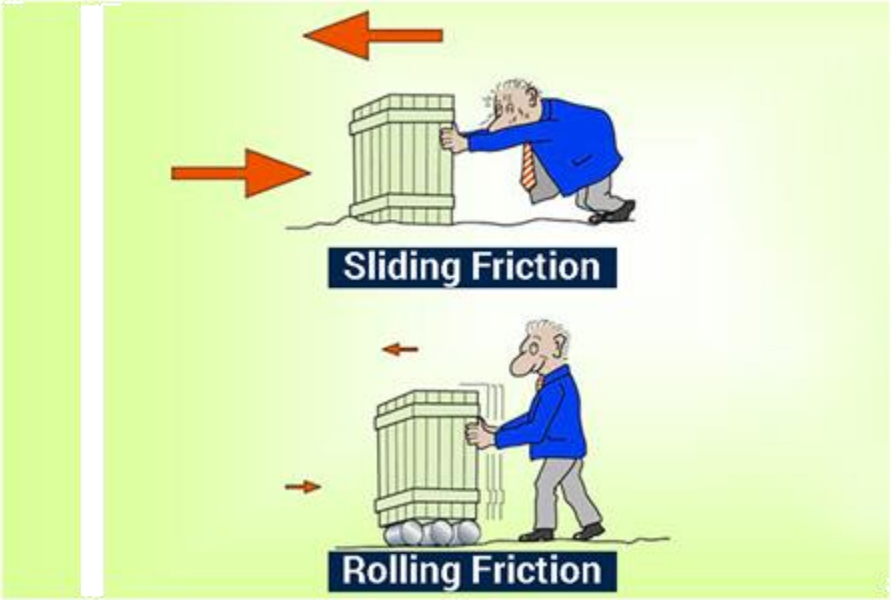
Dynamic Friction

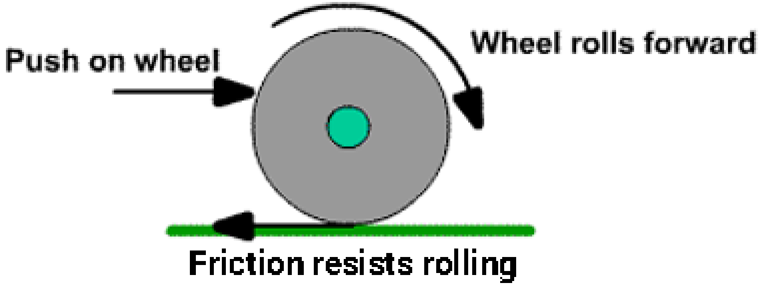
When the value of applied force exceeds the limiting friction then body starts moving over another body and frictional force experienced by body is called Dynamic Friction.

Friction Vs Applied force



Classification of Kinetic Friction

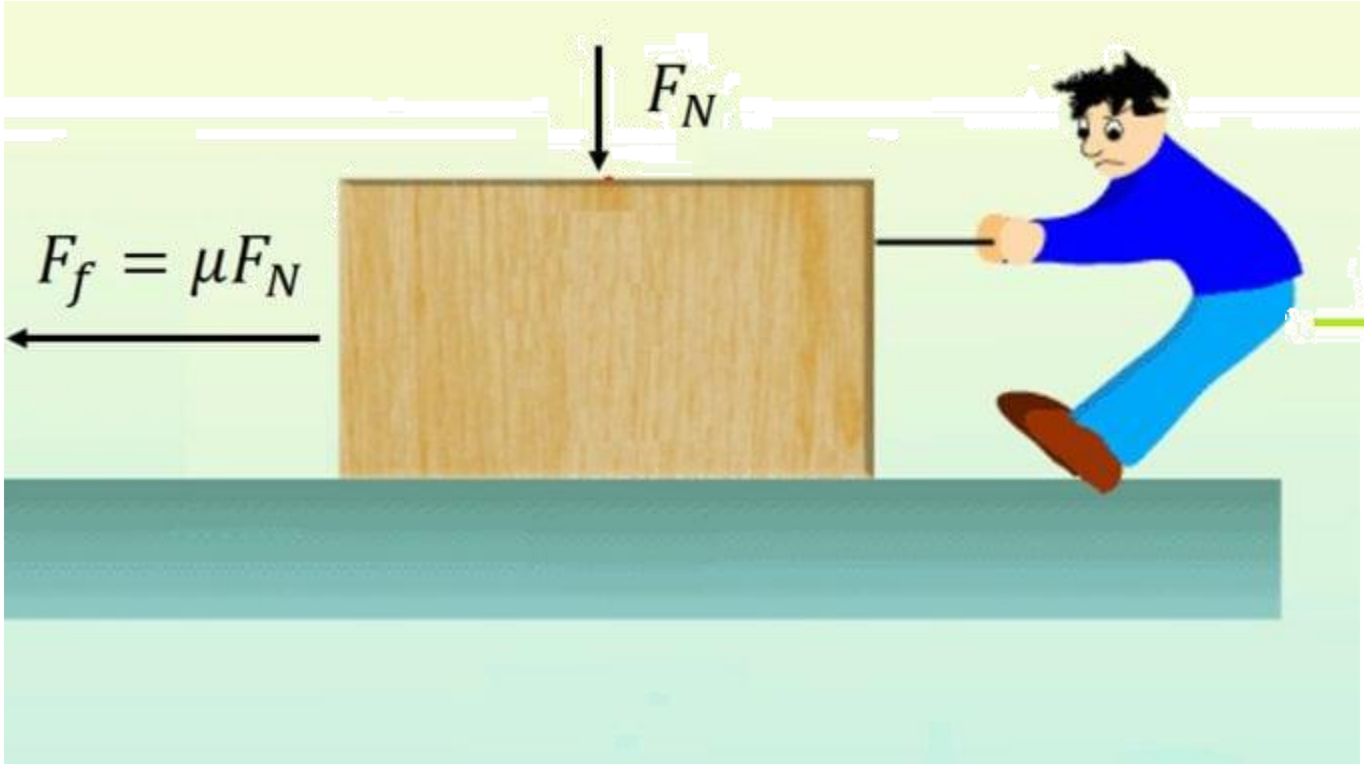


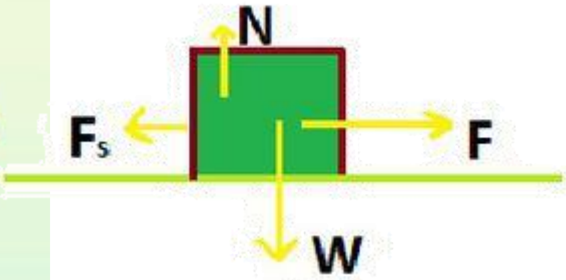


Laws of Friction/Static Friction(Coulomb's Law of friction)

- The force of friction always acts in a direction, opposite to that in which the body tends to move, if the force of friction would have been absent.
- 2. The magnitude of the force of friction is exactly equal to the force, which tends to move the body.
- 3. The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two surfaces.
- 4. The force of friction is independent of the area of contact between the two surfaces.
- 5. The force of friction depends upon the roughness of the surfaces.

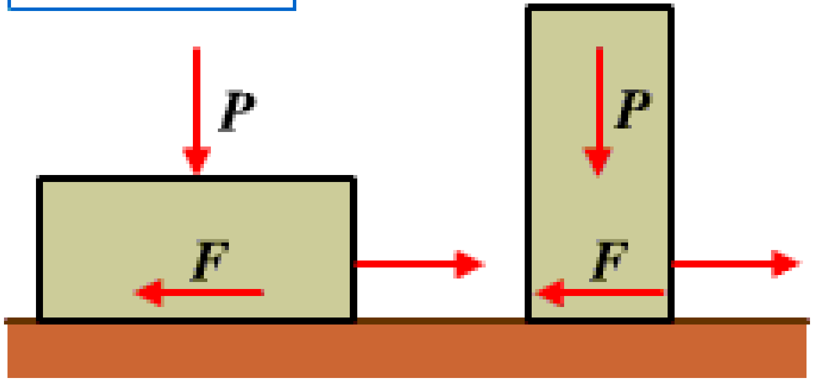
The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two surfaces.





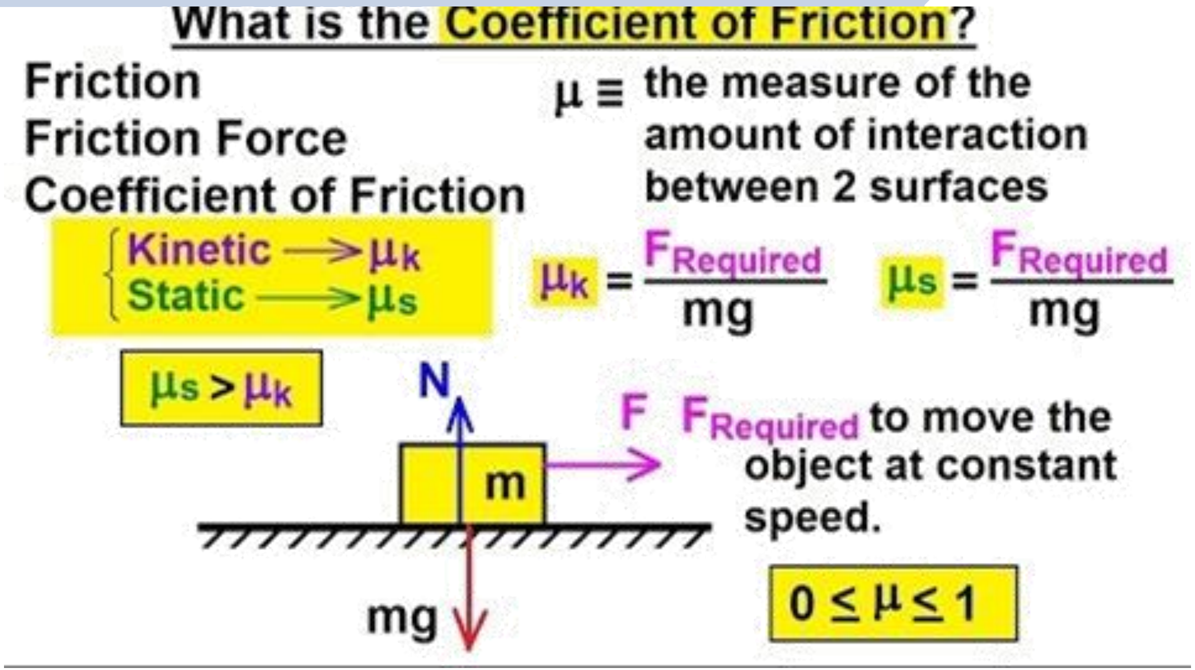
The force of friction is independent of the area of contact between the two surfaces.

$$F = \mu P$$

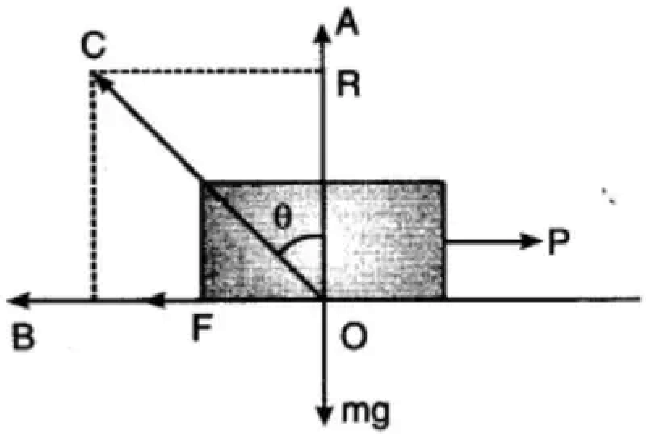


Coulomb's Laws of Friction
(Friction is proportional to the load pressing the solids together and almost independent of the area of contact.)

Co-efficient of Friction



Angle of Friction(ø)

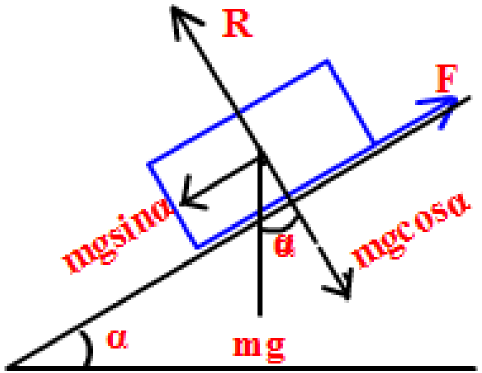


Relation :

In ΔAOC $\tan\theta = \frac{AC}{OA} = \frac{OB}{OA} = \frac{F}{R} = \mu$

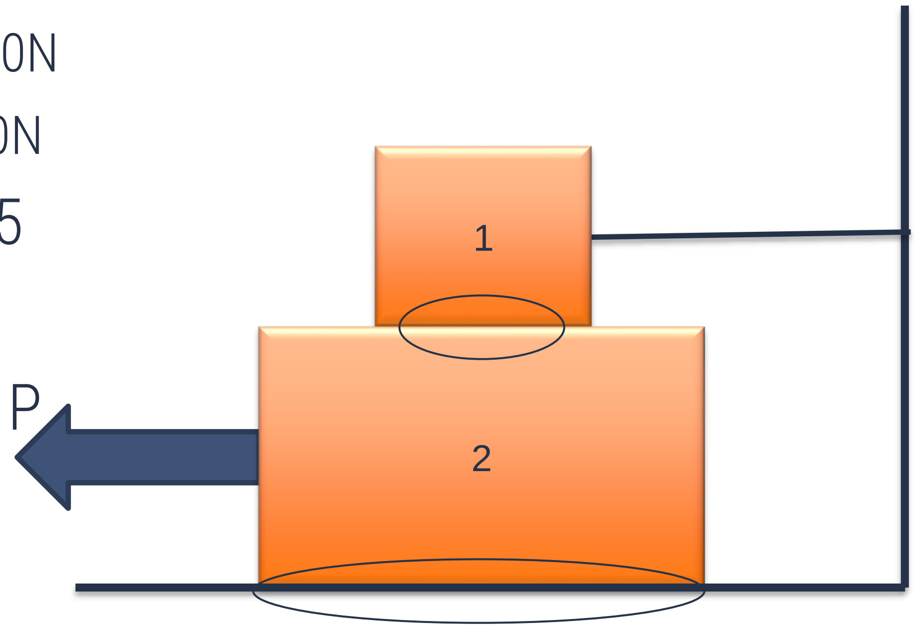
Hence $\mu = \tan\theta$

Angle of Repose



Problems

- $W_1=1000N$
- $W_2=2000N$
- $\mu 1=0.25$
- $\mu 2=1/3$
-

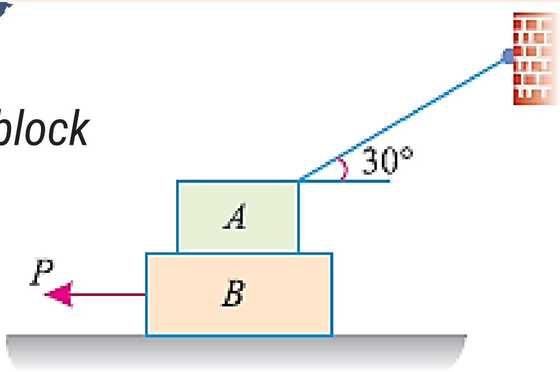


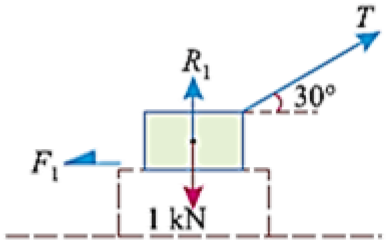
2.What is the value of P when P is making 30 degree upward from horizontal?

- 1.What is the value of P when it is horizontal?

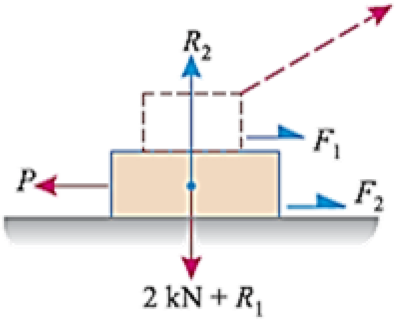
👉Two blocks A and B of weights 1 kN and 2 kN respectively are in equilibrium position as shown in Fig

- *If the coefficient of friction between the two blocks as well as the block B and the floor is 0.3,*
- *find the force (P) required to move the block B.*





(a) Block A



(b) Block B

Solution. Given: Weight of block A $(W_A) = 1$ kN; Weight of block B $(W_B) = 2$ kN and coefficient of friction $(\mu) = 0.3$.

(a) Block A (b) Block B

Fig. 8.5.

The forces acting on the two blocks A and B are shown in Fig. 8.5 (*a*) and (*b*) respectively. First of all, consider the forms acitng in the block A.

Resolving the forces vertically,

$$R_1 + T \sin 30° = 1 \text{ kN}$$

or $$T \sin 30° = 1 - R_1 \quad \text{...}(i)$$

and now resolving the forces horizontally,

$$T \cos 30° = F_1 = \mu R_1 = 0.3 R_1 \quad \text{...}(ii)$$

Dividing equation (*i*) by (*ii*)

$$\frac{T \sin 30°}{T \cos 30°} = \frac{1 - R_1}{0.3 R_1} \quad \text{or} \quad \tan 30° = \frac{1 - R_1}{0.3 R_1}$$

$\therefore \quad 0.5774 = \dfrac{1 - R_1}{0.3 R_1}$ or $0.5774 \times 0.3 R_1 = 1 - R_1$

or $\quad 0.173 R_1 = 1 - R_1$ or $1.173 R_1 = 1$

or $\quad R_1 = \dfrac{1}{1.173} = 0.85$ kN

and $\quad F_1 = \mu . R_1 = 0.3 \times 0.85 = 0.255$ kN ...(*iii*)

Now consider the block *B*. A little consideration will show that the downward force of the block *A* (equal to R_1) will also act alongwith the weight of the block *B*.

Resolving the forces vertically,

$$R_2 = 2 + R_1 = 2 + 0.85 = 2.85 \text{ kN}$$

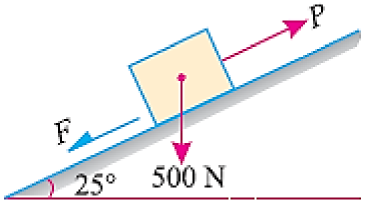
$$\therefore \quad F_2 = \mu R_2 = 0.3 \times 2.85 = 0.855 \text{ kN}$$

and now resolving the forces horizontally,

$$P = F_1 + F_2 = 0.255 + 0.855 = 1.11 \text{ kN} \qquad \textbf{Ans.}$$

Problems

- *A body of weight 500 N is lying on a rough plane inclined at an angle of25° with the horizontal. It is supported by an effort (P) parallel to the plane as shown in Fig. Determine the minimum and maximum values of P, for which the equilibrium can exist, if the angle of friction is 20° .*



Solution. Given: Weight of the body (W) = 500 N ; Angle at which plane is inclined (α) = 25° and angle of friction (ϕ) = 20°.

Minimum value of P

We know that for the minimum value of P, the body is at the point of sliding downwards. We also know that when the body is at the point of sliding downwards, then the force

$$P_1 = W \times \frac{\sin(\alpha - \phi)}{\cos\phi} = 500 \times \frac{\sin(25^\circ - 20^\circ)}{\cos 20^\circ} \text{ N}$$

$$= 500 \times \frac{\sin 5^\circ}{\cos 20^\circ} = 500 \times \frac{0.0872}{0.9397} = 46.4 \text{ N} \qquad \textbf{Ans.}$$

Maximum value of P

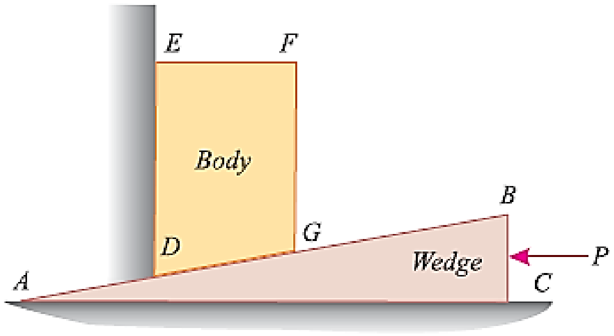
We know that for the maximum value of P, the body is at the point of sliding upwards. We also know that when the body is at the point of sliding upwards, then the force

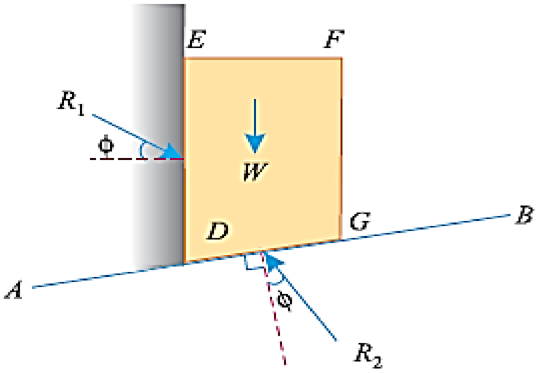
$$P_2 = W \times \frac{\sin(\alpha + \phi)}{\cos\phi} = 500 \times \frac{\sin(25^\circ + 20^\circ)}{\cos 20^\circ} \text{ N}$$

$$= 500 \times \frac{\sin 45^\circ}{\cos 20^\circ} = 500 \times \frac{0.7071}{0.9397} = 376.2 \text{ N} \qquad \textbf{Ans.}$$

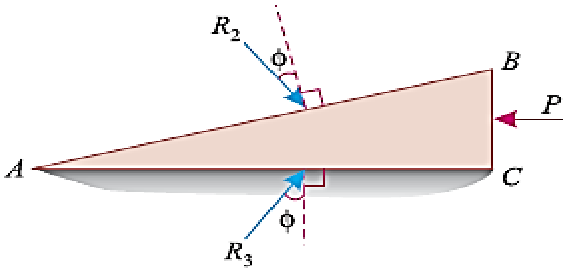
WEDGE FRICTION

- A wedge is, usually, of a triangular or trapezoidal in cross-section. It is, generally, used for slight adjustments in the position of a body *i.e.* for tightening fits or keys for shafts. Sometimes, a wedge is also used for lifting heavy weights as shown in Fig





(*a*) Forces on the body *DEFG*

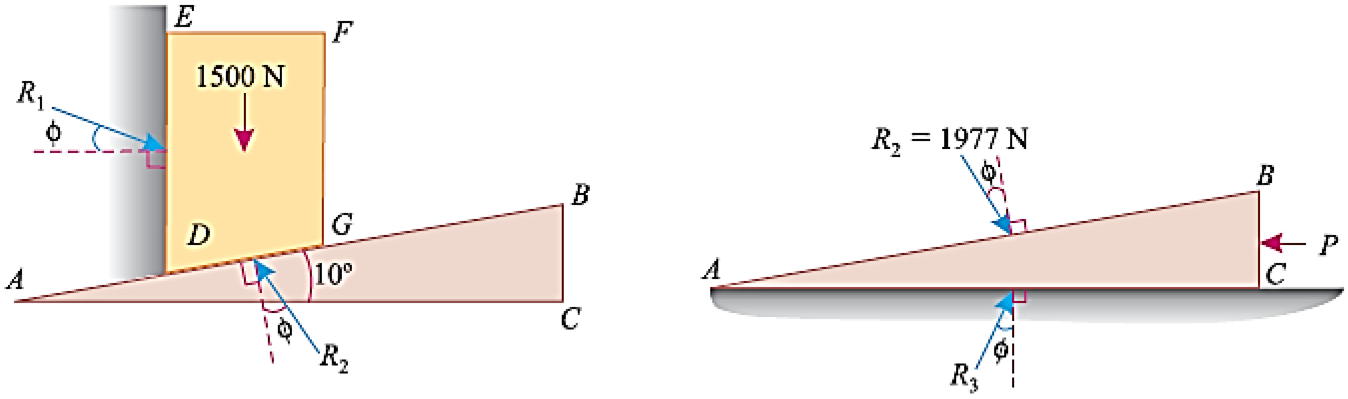


(*a*) Forces on the wedge *ABC*

Problem

- A block weighing 1500 N, overlying a 10° wedge on a horizontal floor and leaning against a vertical wall, is to be raised by applying a horizontal force to the wedge. Assuming the coefficient of friction between all the surface in contact to be 0.3, determine the minimum horizontal force required to raise the block.

Analytical method



(*a*) Block *DEFG* (*b*) Wedge *ABC*

Fig. 9.14.

First of all, consider the equilibrium of the block. We know that it is in equilibrium under the action of the following forces as shown in Fig. 9.14 (*a*).

1. Its own weight 1500 N acting downwards.
2. Reaction R_1 on the face *DE*.
3. Reaction R_2 on the face *DG* of the block.

Resolving the forces horizontally,

$$R_1 \cos(16.7°) = R_2 \sin(10 + 16.7°) = R_2 \sin 26.7°$$

$$R_1 \times 0.9578 = R_2 \times 0.4493$$

or $$R_2 = 2.132\, R_1$$

and now resolving the forces vertically,

$$R_1 \times \sin(16.7°) + 1500 = R_2 \cos(10° + 16.7°) = R_2 \cos 26.7°$$

$$R_1 \times 0.2874 + 1500 = R_2 \times 0.8934 = (2.132\, R_1)0.8934$$

$$= 1.905\, R_1 \qquad \ldots(R_2 = 2.132\, R_1)$$

$$R_1(1.905 - 0.2874) = 1500$$

$$\therefore \qquad R_1 = \frac{1500}{1.6176} = 927.3 \text{ N}$$

and $$R_2 = 2.132\, R_1 = 2.132 \times 927.3 = 1977 \text{ N}$$

Now consider the equilibrium of the wedge. We know that it is in equilibrium under the action of the following forces as shown in Fig. 9.14 (*b*).

1. Reaction R_2 of the block on the wedge.
2. Force (P) acting horizontally, and
3. Reaction R_3 on the face AC of the wedge.

Resolving the forces vertically,

$$R_3 \cos 16.7° = R_2 \cos (10° + 16.7°) = R_2 \cos 26.7°$$

$$R_3 \times 0.9578 = R_2 \times 0.8934 = 1977 \times 0.8934 = 1766.2$$

$$\therefore \qquad R_3 = \frac{1766.2}{0.9578} = 1844 \text{ N}$$

and now resolving the forces horizontally,

$$P = R_2 \sin (10° + 16.7°) + R_3 \sin 16.7° = 1977 \sin 26.7° + 1844 \sin 16.7° \text{ N}$$

$$= (1977 \times 0.4493) + (1844 \times 0.2874) = 1418.3 \text{ N} \qquad \textbf{Ans.}$$

Slove it???

A 15° wedge (A) has to be driven for tightening a body (B) loaded with 1000 N weight as shown in Fig. 9.15.

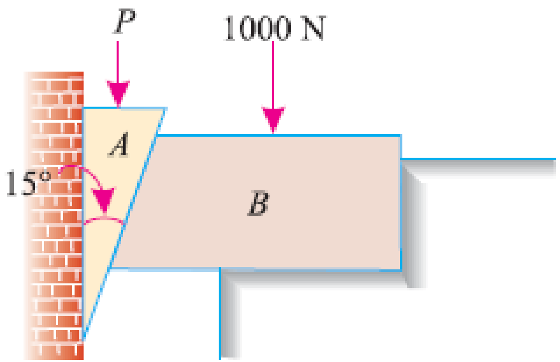


Fig. 9.15.

If the angle of friction for all the surfaces is 14°, find graphically the force (P), which should be applied to the wedge. Also check the answer analytically.

THANKS!

Any questions?

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