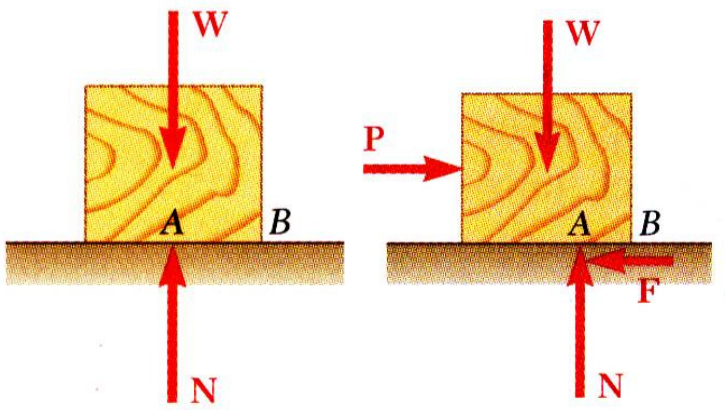
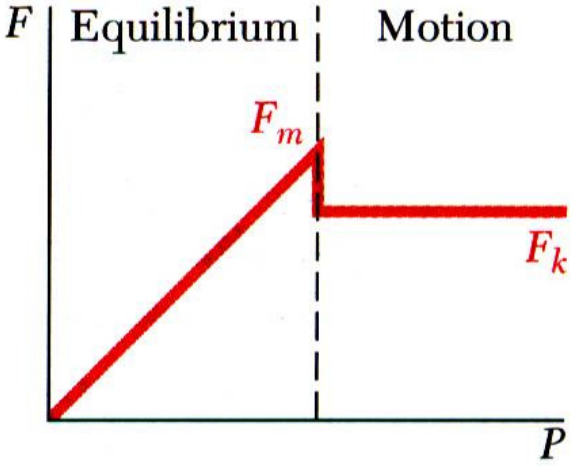
Engineering Mechanics: Statics

The Laws of Dry Friction. Coefficients of Friction





- Block of weight W placed on horizontal surface. Forces acting on block are its weight and reaction of surface N.
- Small horizontal force P applied to block. For block to remain stationary, in equilibrium, a horizontal component F of the surface reaction is required. F is a *static-friction force*.
- As P increases, the static-friction force F increases as well until it reaches a maximum value F_m.

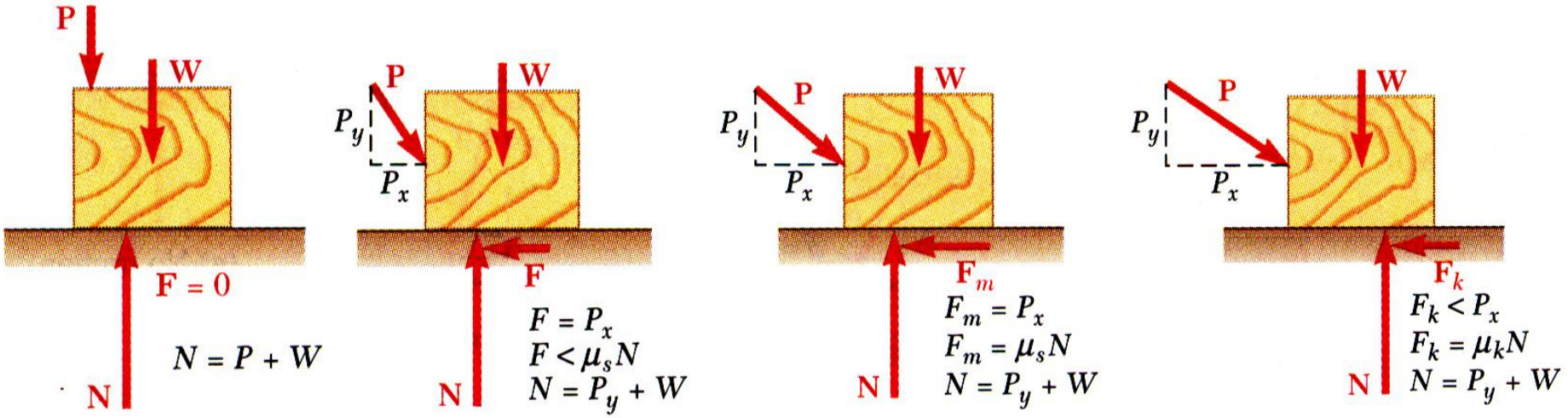
$$F_m = \mu_s N$$

- Further increase in P causes the block to begin to move as F drops to a smaller *kinetic-friction force* F_k.

$$F_k = \mu_k N$$

The Laws of Dry Friction. Coefficients of Friction

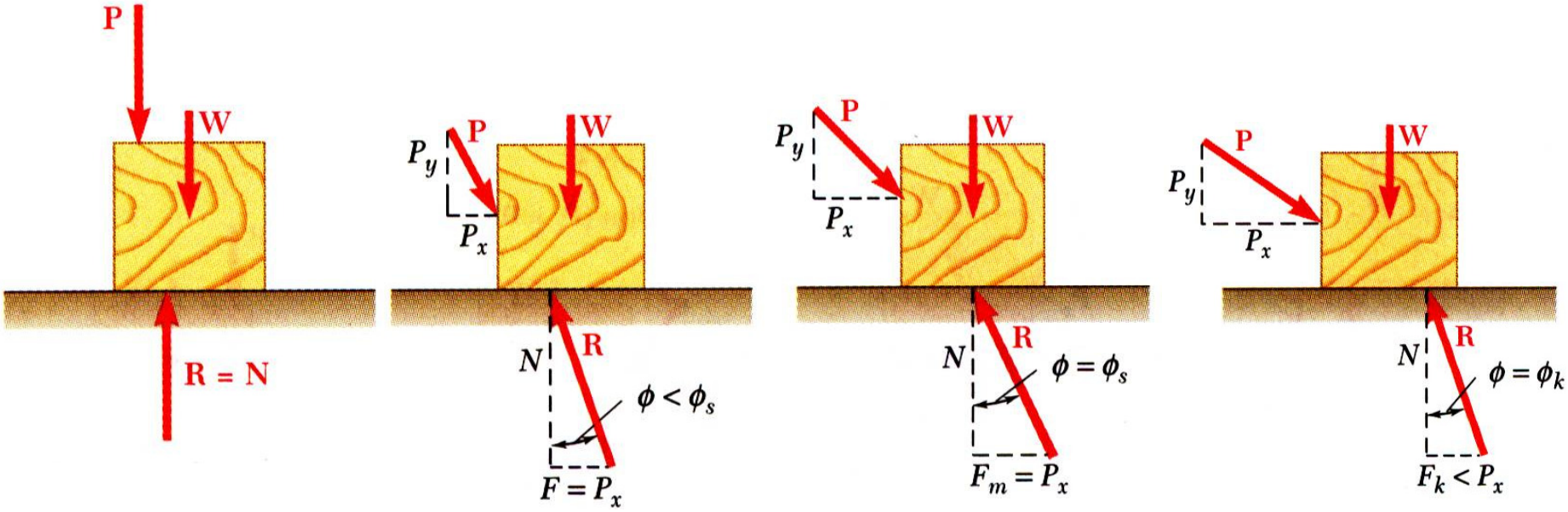
- Four situations can occur when a rigid body is in contact with a horizontal surface:



- No friction, $(P_x = 0)$
- No motion, $(P_x < F_m)$
- Motion impending, $(P_x = F_m)$
- Motion, $(P_x > F_m)$

Angles of Friction

- It is sometimes convenient to replace normal force N and friction force F by their resultant $\boldsymbol{R}$:



- No friction
- No motion
- Motion impending
- Motion

$$\tan\phi_s = \frac{F_m}{N} = \frac{\mu_s N}{N}$$

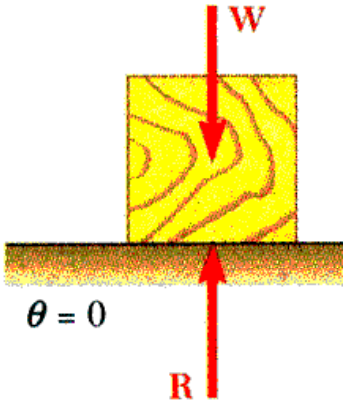
$$\tan\phi_s = \mu_s$$

$$\tan\phi_k = \frac{F_k}{N} = \frac{\mu_k N}{N}$$

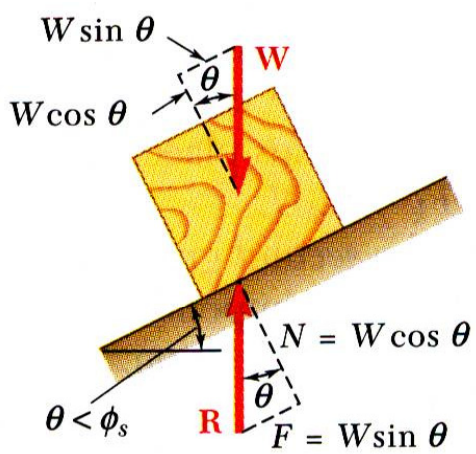
$$\tan\phi_k = \mu_k$$

Angles of Friction

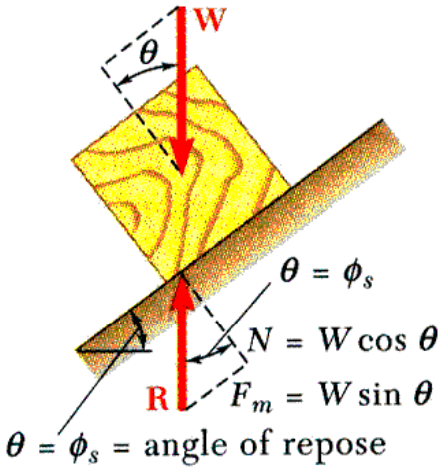
- Consider block of weight W resting on board with variable inclination angle θ.



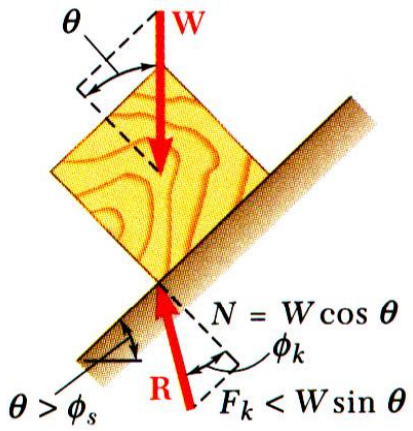
- No friction



- No motion

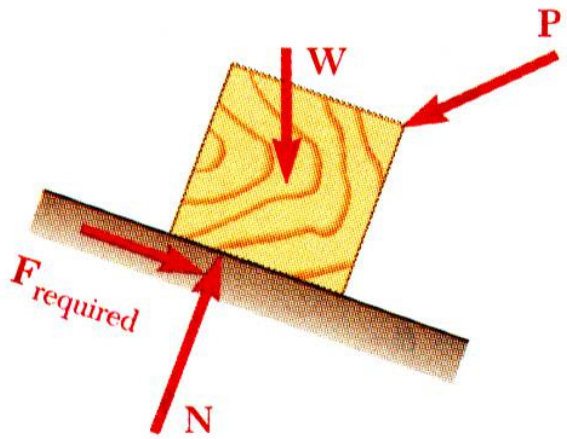


- Motion impending

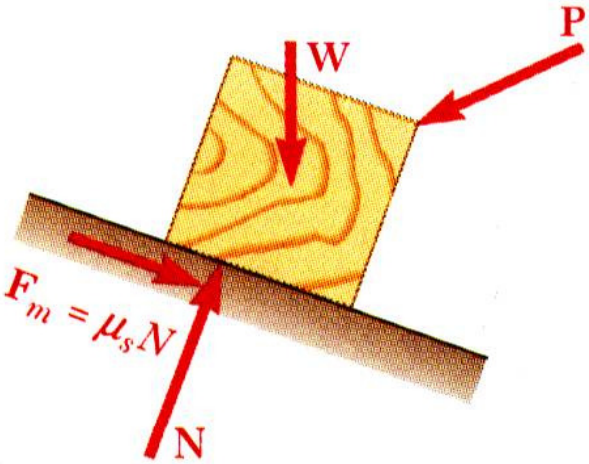


- Motion

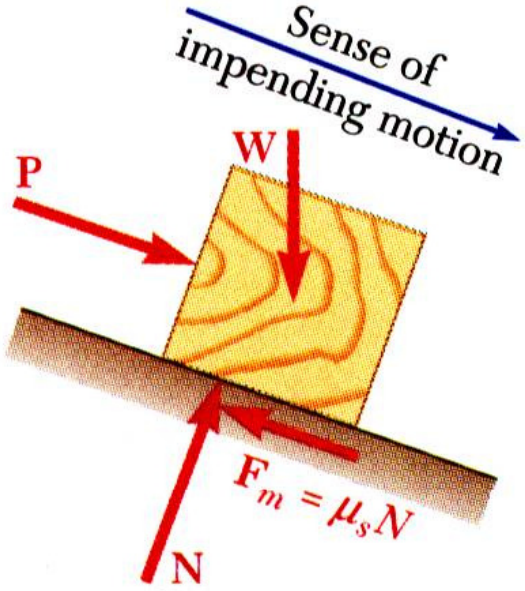
Problems Involving Dry Friction



- All applied forces known
- Coefficient of static friction is known
- Determine whether body will remain at rest or slide

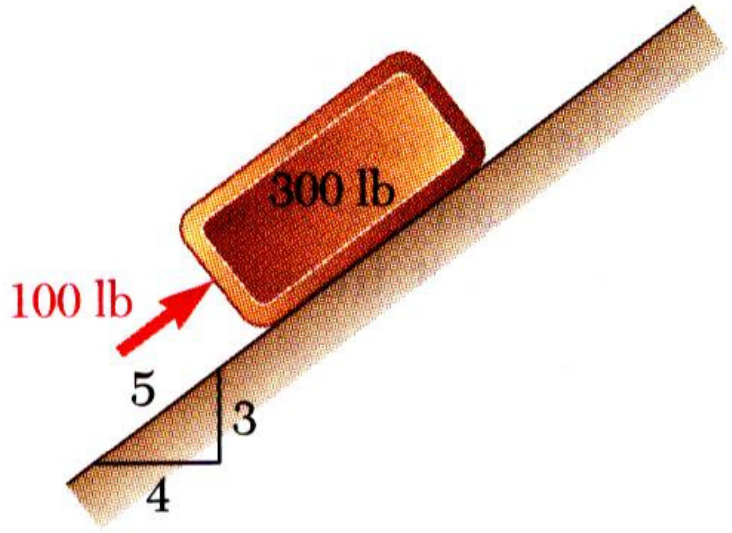


- All applied forces known
- Motion is impending
- Determine value of coefficient of static friction.



- Coefficient of static friction is known
- Motion is impending
- Determine magnitude or direction of one of the applied forces

Sample Problem

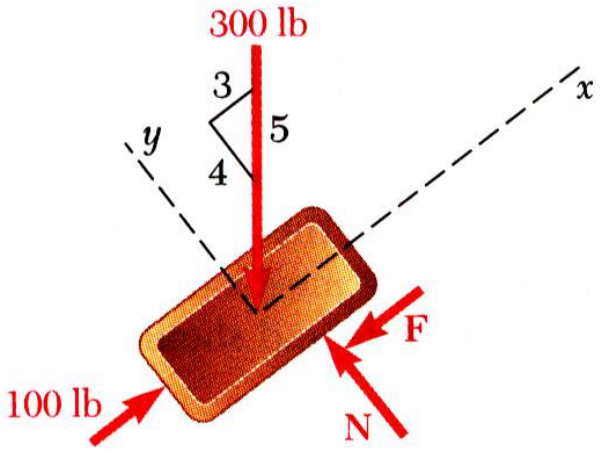


A 100 lb force acts as shown on a 300 lb block placed on an inclined plane. The coefficients of friction between the block and plane are $\mu_s = 0.25$ and $\mu_k = 0.20$. Determine whether the block is in equilibrium and find the value of the friction force.

SOLUTION:

- Determine values of friction force and normal reaction force from plane required to maintain equilibrium.
- Calculate maximum friction force and compare with friction force required for equilibrium. If it is greater, block will not slide.
- If maximum friction force is less than friction force required for equilibrium, block will slide. Calculate kinetic-friction force.

Sample Problem



SOLUTION:

- Determine values of friction force and normal reaction force from plane required to maintain equilibrium.

$$\sum F_x = 0: \qquad 100\,\text{lb} - \tfrac{3}{5}(300\,\text{lb}) - F = 0$$

$$F = -80\,\text{lb}$$

$$\sum F_y = 0: \qquad N - \tfrac{4}{5}(300\,\text{lb}) = 0$$

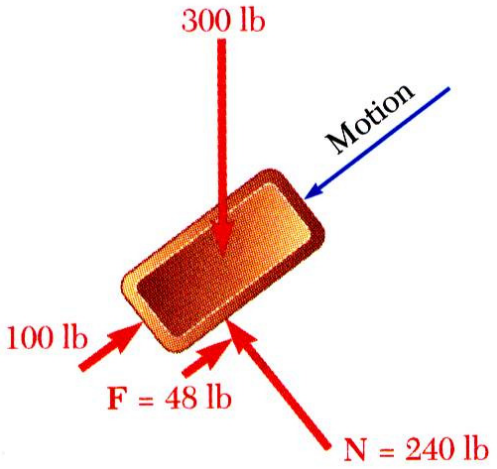
$$N = 240\,\text{lb}$$

- Calculate maximum friction force and compare with friction force required for equilibrium. If it is greater, block will not slide.

$$F_m = \mu_s N \qquad F_m = 0.25(240\,\text{lb}) = 48\,\text{lb}$$

The block will slide down the plane.

Sample Problem



- If maximum friction force is less than friction force required for equilibrium, block will slide. Calculate kinetic-friction force.

$$F_{actual} = F_k = \mu_k N$$
$$= 0.20(240\,\text{lb})$$

$$F_{actual} = 48\,\text{lb}$$