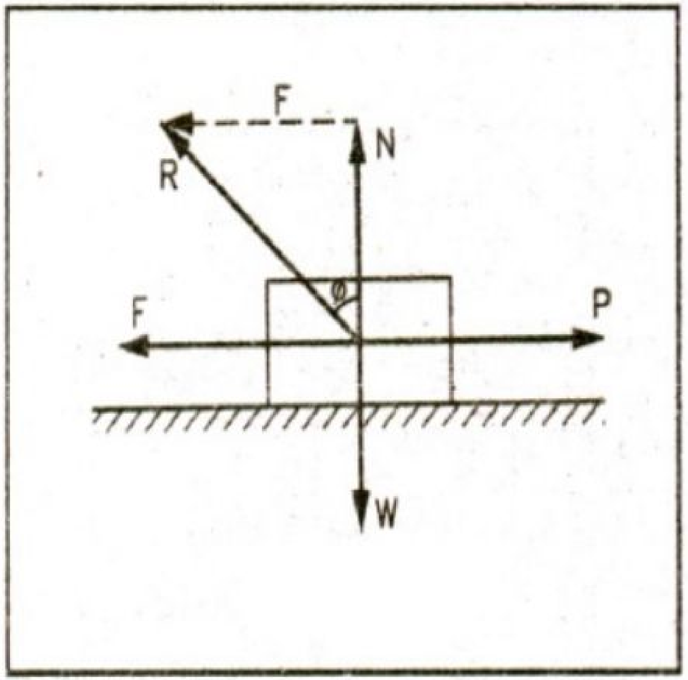
ENGINEERING MECHANICS

Wedge Friction

Department of Civil Engineering

Angle of Friction



W = Weight of block

N = Normal reaction

P = External force

F = Friction force

R = Resultant of N and F.

The angle between normal reaction (N) and resultant force (R) is called **angle of friction.**

It is also called **limiting angle of friction.** The value of ϕ is more for rough surface as compared to smooth surface.

Coefficient of Friction

Limiting friction (F) is proportional to the normal reaction (N).

$\therefore \quad F \propto N$

$\therefore \quad F = \mu \cdot N$

$\therefore \quad \boxed{\mu = \frac{F}{N}} \quad \ldots \text{(i)}$

The ratio of Limiting fricion (F) and Normal reaction (N) is called coefficient of friction.

from figure

$\tan \phi = \frac{F}{N} \quad \ldots \text{(ii)}$

From equation (i) & (ii),

$\therefore \quad \boxed{\mu = \tan \phi} \qquad \therefore \quad \phi = \tan^{-1} \mu$

- **Coefficient of static friction (μ_s) :**

  It is defined as the ratio of the limiting friction force (F) to the normal reaction (N) offered to the body by the surface, provided the body is in impending condition.

  $$\boxed{\mu_s = \frac{F}{N}}$$

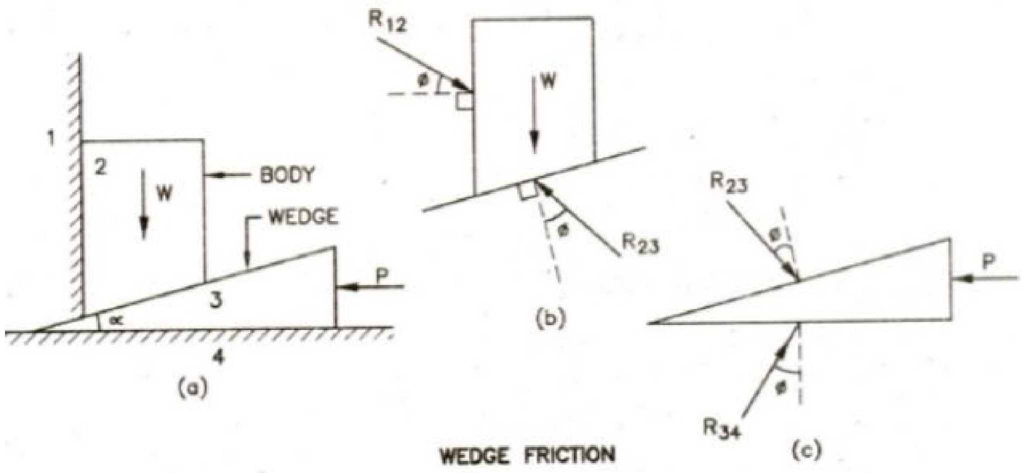
- **Coefficient of kinetic friction (μ_k) :**

  It is defined as the ratio of friction force (F_k) developed while the body is in motion. to the normal reaction (N) developed.

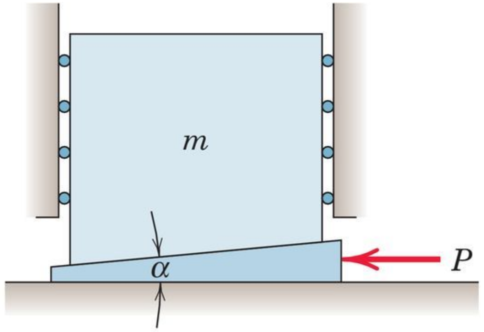
  $$\boxed{\mu_k = \frac{F_k}{N}}$$

- *Wedges are simple machines used to raise large stone blocks and other heavy loads.*
- *These loads can be raised by applying to the wedge a force usually considerably smaller than the weight of the load.*
- *In addition, because of the friction between the surfaces in contact, a properly shaped wedge will remain in place after being forced under the load.*
- *Wedges can thus be used advantageously to make small adjustments in the position of heavy pieces of machinery.*

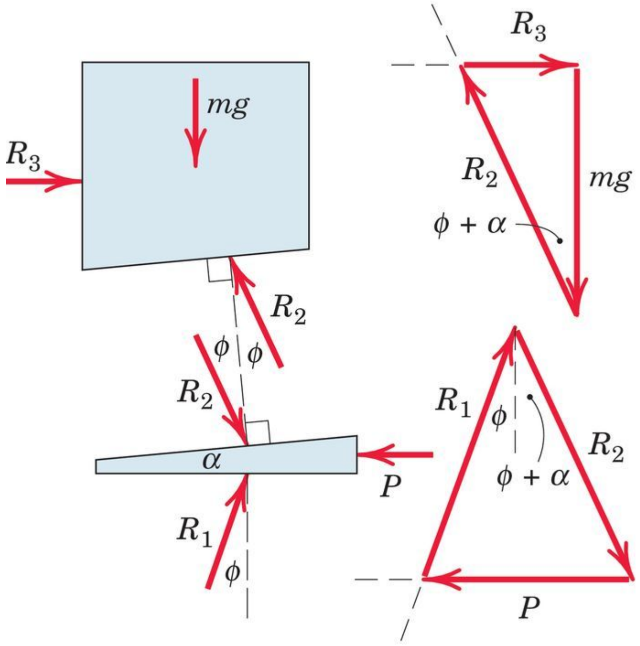
WEDGE FRICTION



ENGINEERING MECHANICS
Wedge Friction



(a)



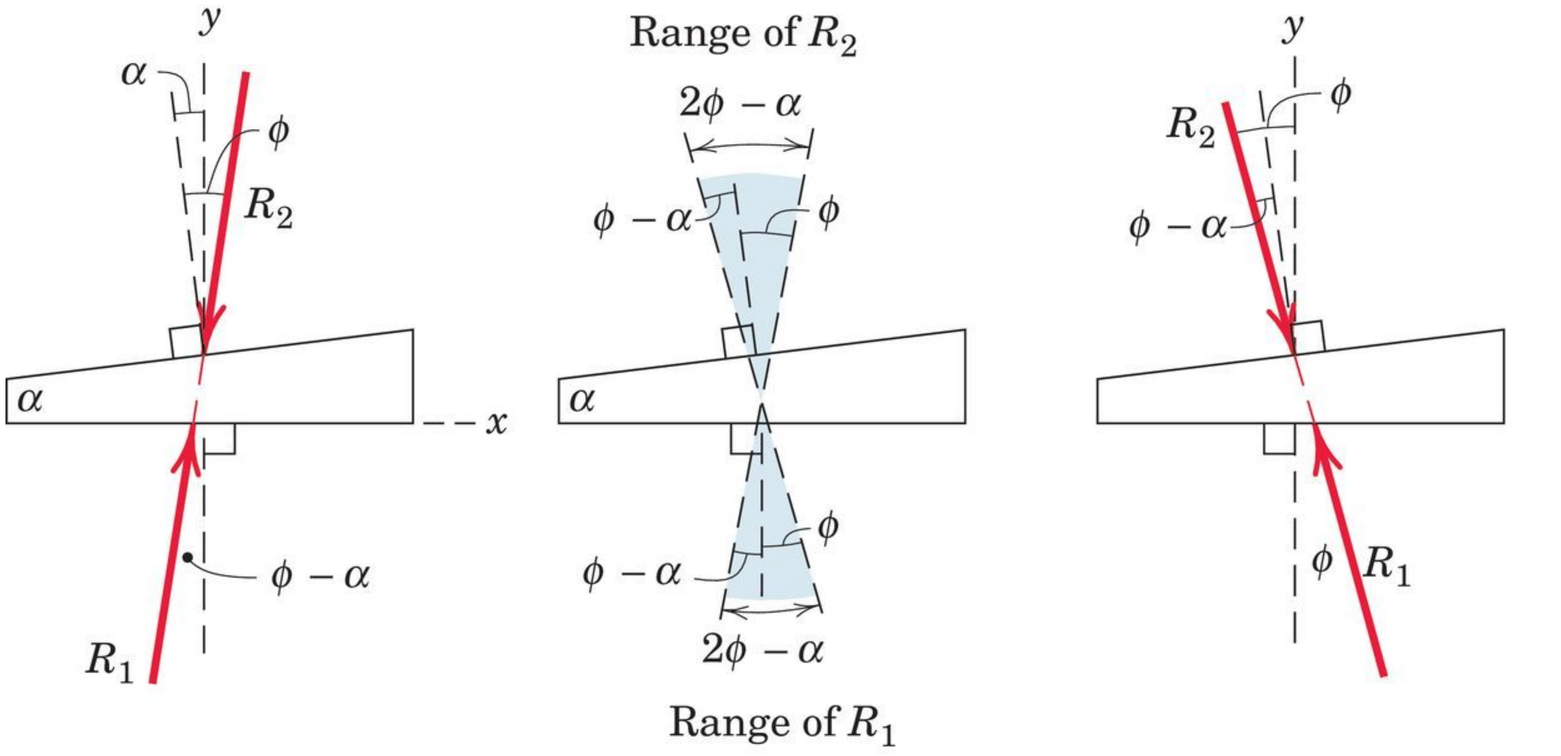
(b) (c)

Forces to raise load

Wedge Friction

Wedges are used as shown to split tree trunks because the normal forces exerted by the wedges on the wood are much larger than the forces required to insert the wedges.

Wedge Friction

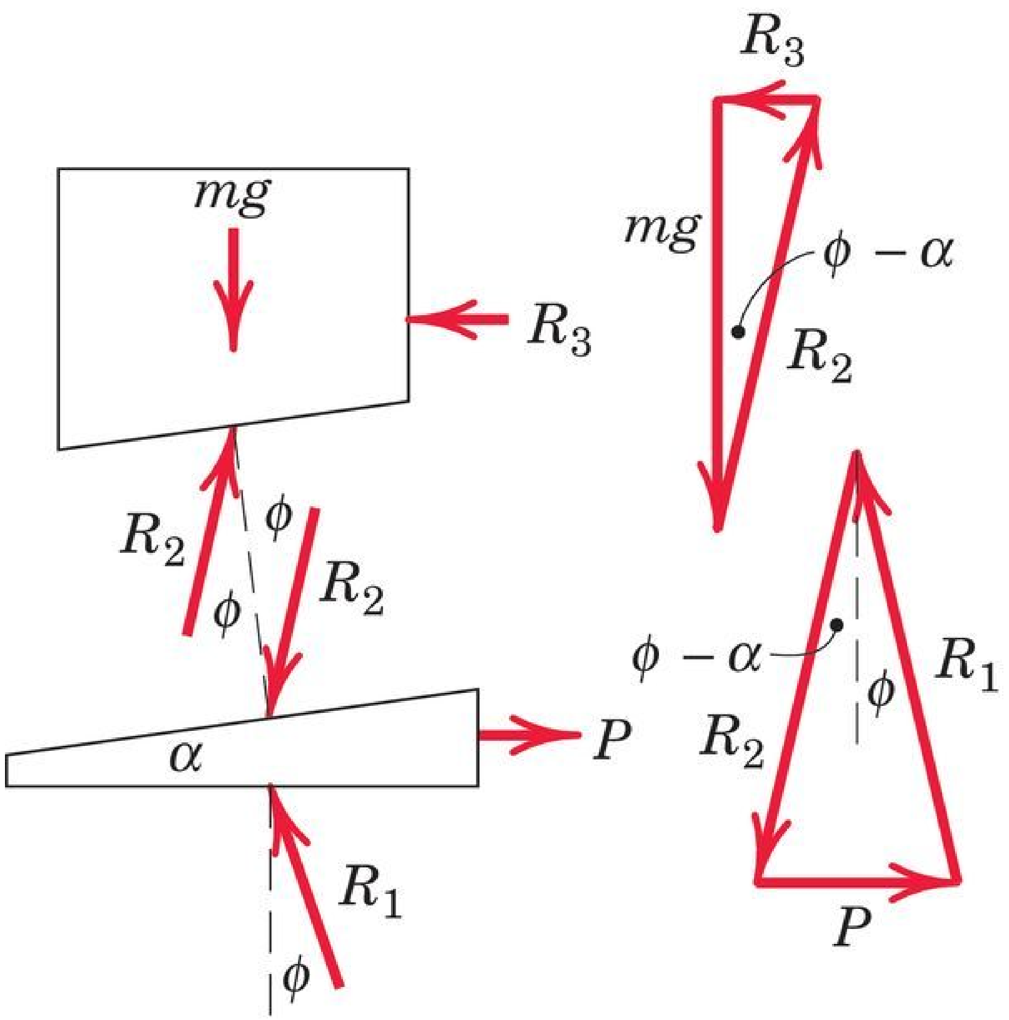


(a) Slipping impending at upper surface

(b) Range of $R_1 = R_2$ for no slip

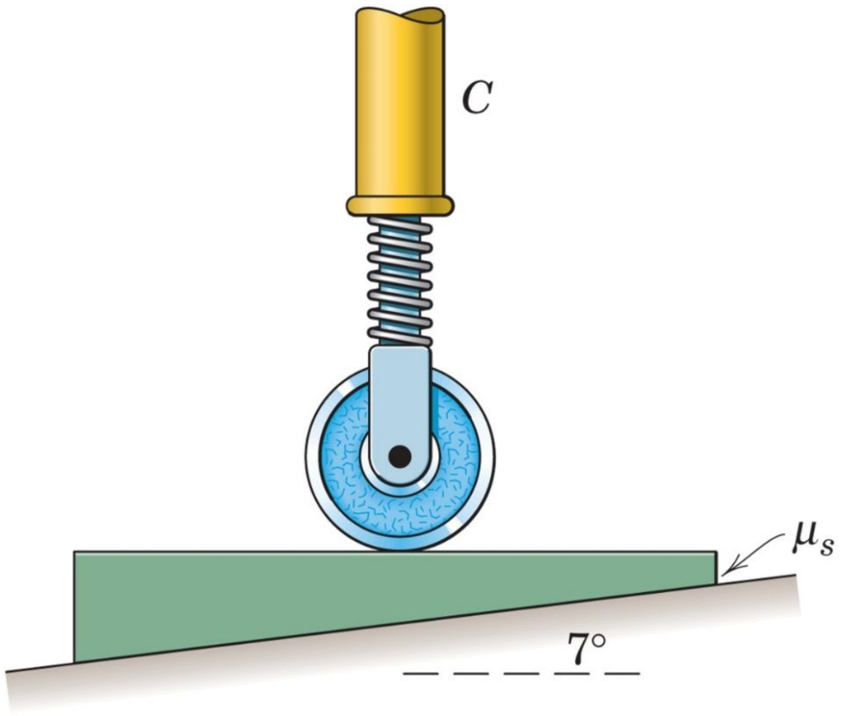
(c) Slipping impending at lower surface

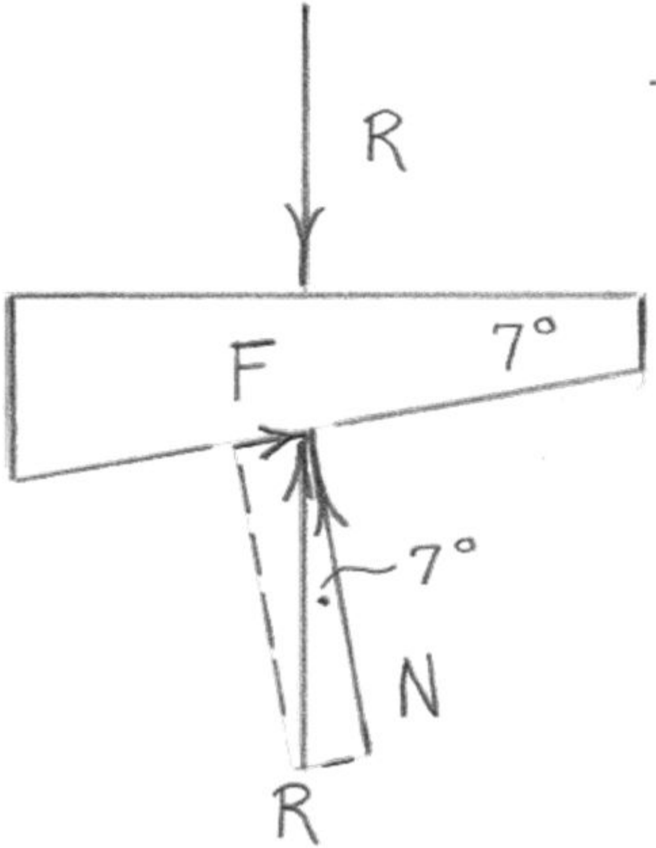
Wedge Friction



Forces to lower load

6/53 The 7° wedge is driven under the spring-loaded wheel whose supporting strut C is fixed. Determine the minimum coefficient of static friction μs for which the wedge will remain in place. Neglect all friction associated with the wheel

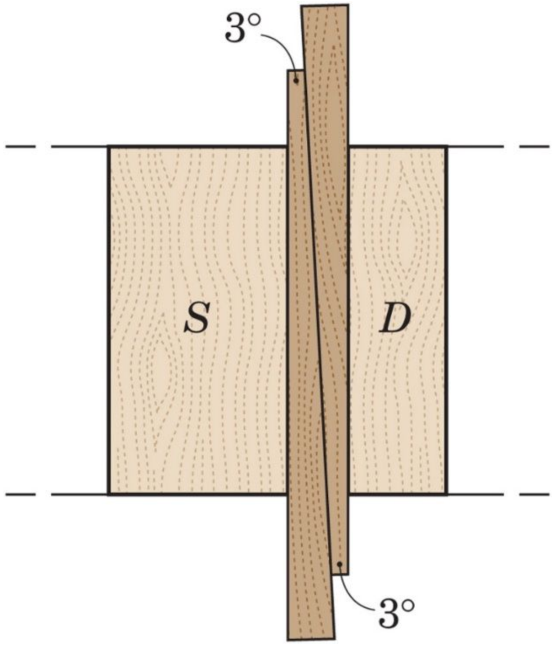




$$\frac{F}{N} = \mu_s = \tan 7^\circ$$

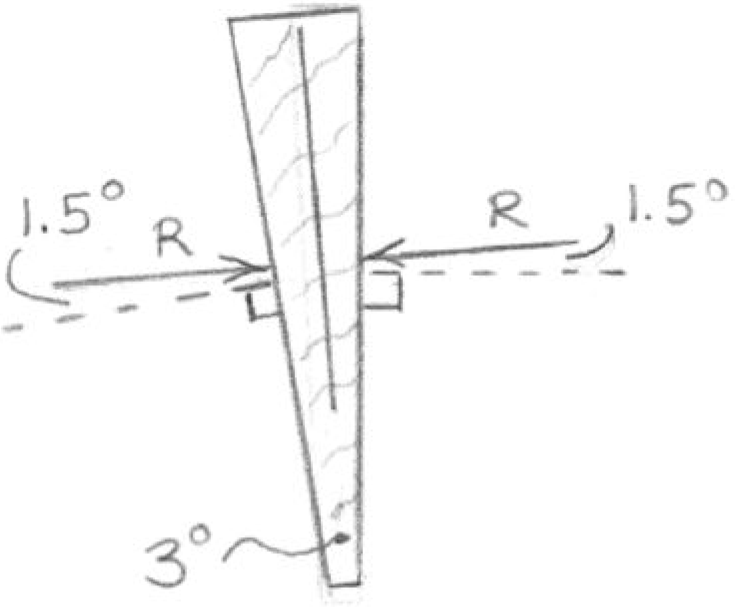
$$\underline{\mu_s = 0.1228}$$

6/55 In wood-frame construction, two shims are frequently used to fill the gap between the framing S and the thinner window/door jamb D. The members S and D are shown in cross section in the figure. For the 3° shims shown, determine the minimum necessary coefficient of static friction so that the shims will remain in place.



Wedge Friction

Consider the right shim (3° angle exaggerated)

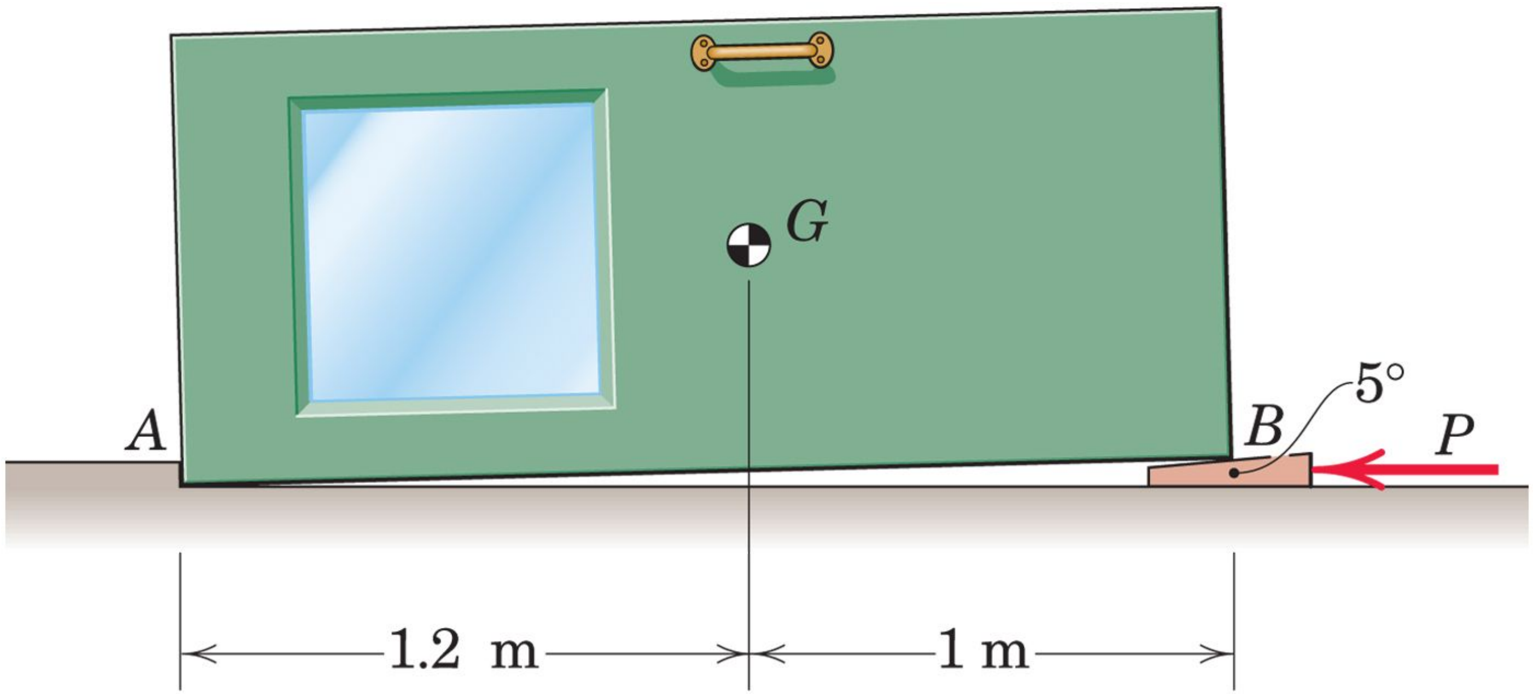


$$\mu_s = \tan\phi = \tan 1.5^\circ$$

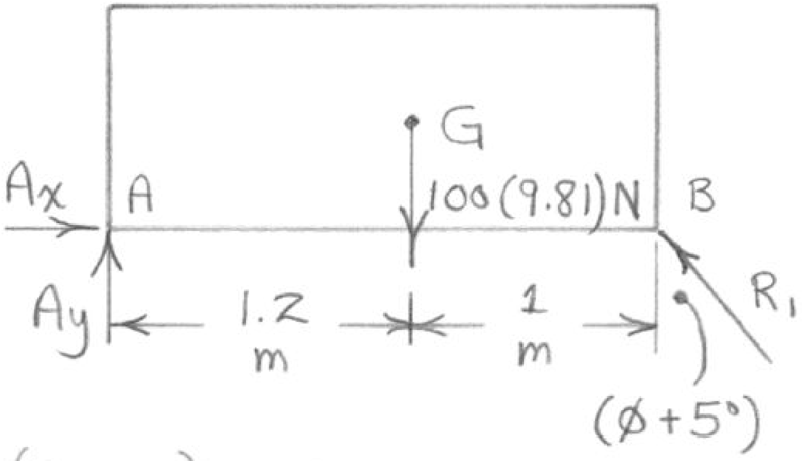
$$= \underline{0.0262}$$

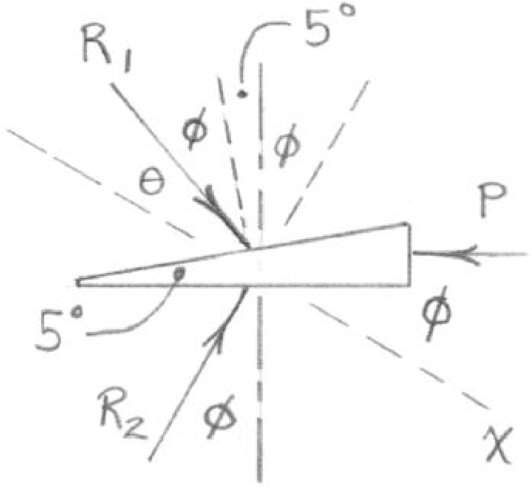
(A very modest requirement !)

6/56 The 100-kg industrial door with mass center at G is being positioned for repair by insertion of the 5^0 wedge under corner B. Horizontal movement is prevented by the small ledge at corner A. If the coefficients of static friction at both the top and bottom wedge surfaces are 0.60, determine the force P required
to lift the door at B.



$$\phi = \tan^{-1}(0.60) = 31.0^\circ$$





(Door)

$$\Sigma M_A = 0: \quad R_1 \cos(31.0^\circ + 5^\circ)(2.2) - 100(9.81)(1.2) = 0$$

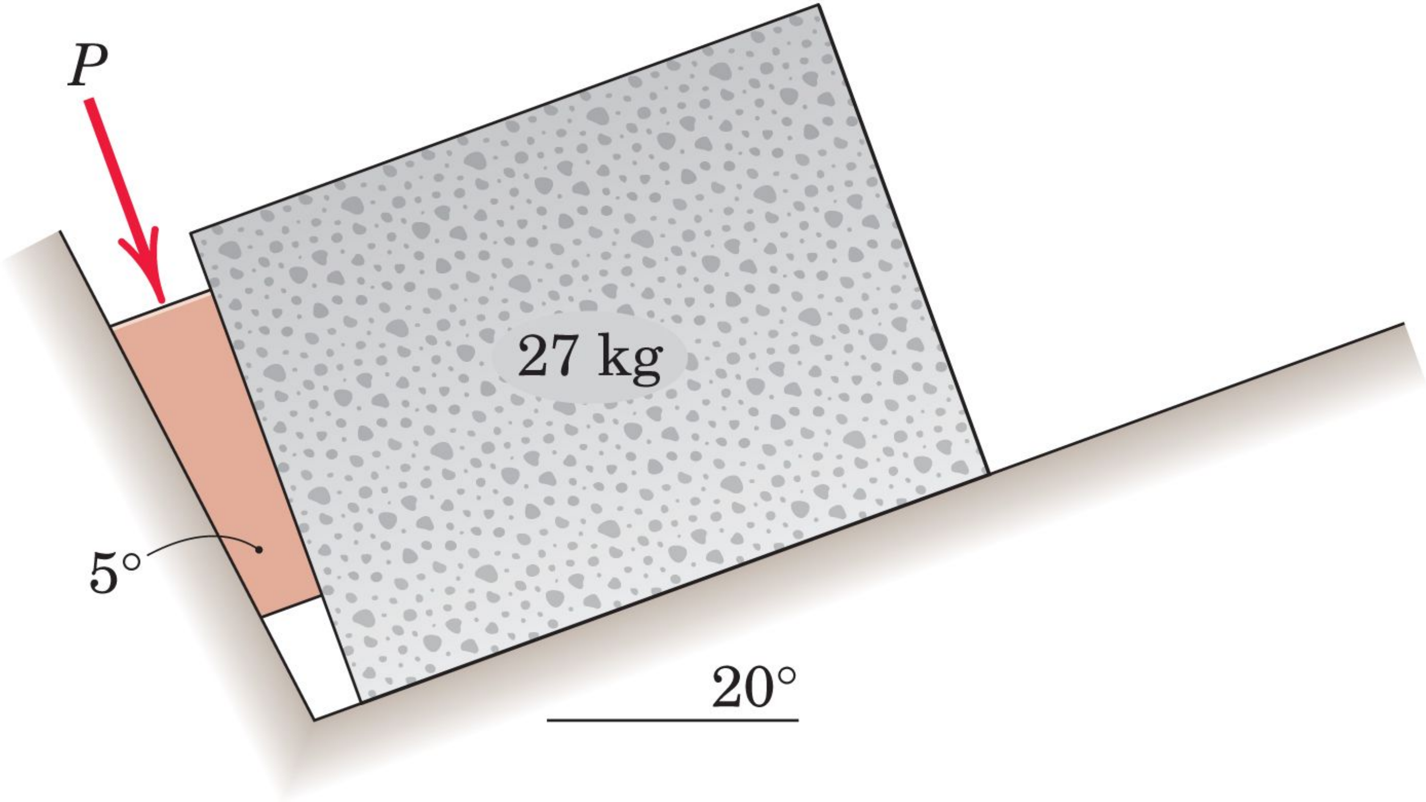
$$R_1 = 661 \text{ N}$$

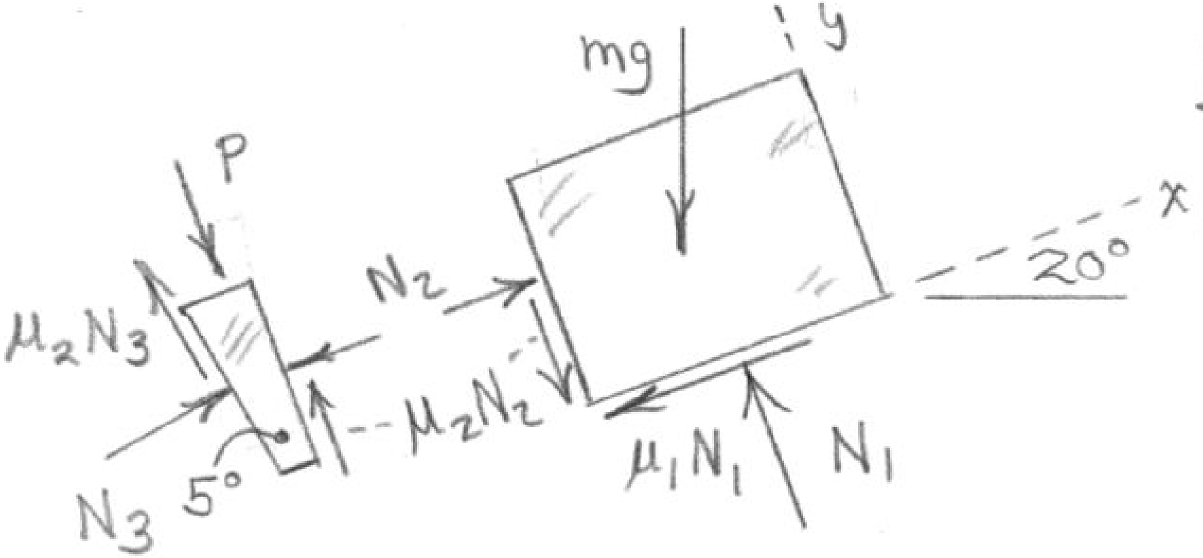
(Wedge) (Note $\theta = 90^\circ - 2\phi - 5^\circ = 23.1^\circ$)

$$\Sigma F_x = 0: \quad 661 \cos 23.1^\circ - P \cos 31.0^\circ = 0$$

$$\underline{P = 709 \text{ N}}$$

6/66 The coefficient of static friction for both wedge surfaces is 0.40 and that between the 27-kg concrete block and the 20° incline is 0.70. Determine the minimum value of the force P required to begin moving the block up the incline. Neglect the weight of the wedge.





$$\begin{cases} \mu_1 = 0.7 \\ \mu_2 = 0.4 \end{cases}$$

$$mg = 27(9.81)\,N$$

Block:

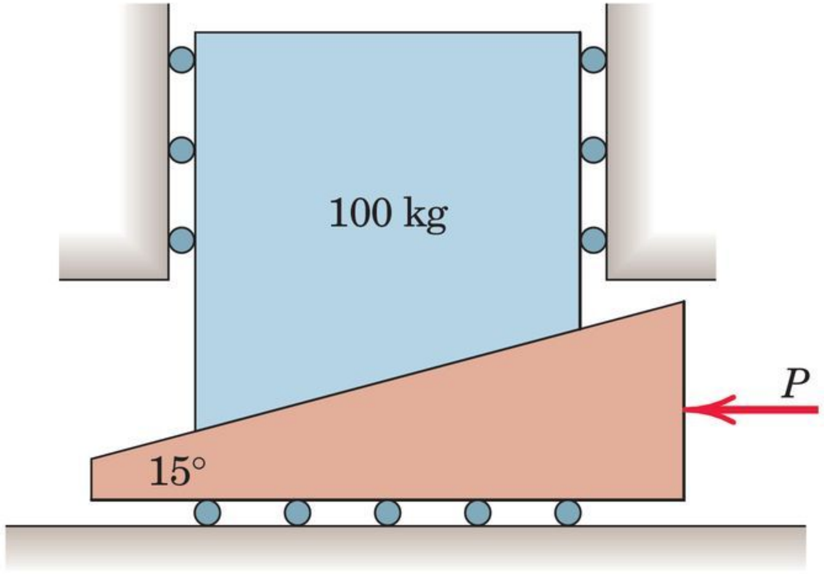
$$\begin{cases} \Sigma F_x = 0: \quad -mg\sin 20^\circ + N_2 - \mu_1 N_1 = 0 & (1) \\ \Sigma F_y = 0: \quad -mg\cos 20^\circ + N_1 - \mu_2 N_2 = 0 & (2) \end{cases}$$

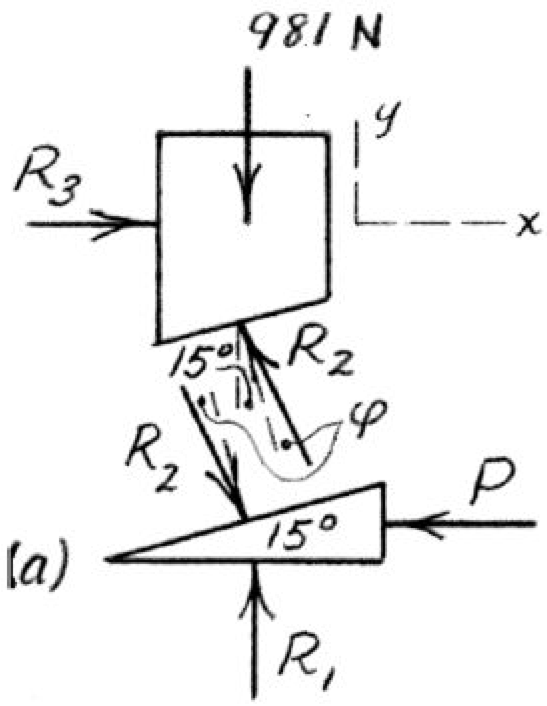
Wedge :

$$\begin{cases} \Sigma F_x = 0: & N_3 \cos 5^\circ - \mu_2 N_3 \sin 5^\circ - N_2 = 0 \quad (3) \\ \Sigma F_y = 0: & N_3 \sin 5^\circ + \mu_2 N_3 \cos 5^\circ + \mu_2 N_2 - P = 0 \quad (4) \end{cases}$$

Solution : $\begin{cases} N_1 = 396 \text{ N} & N_2 = 368 \text{ N} \\ N_3 = 383 \text{ N} & \underline{P = 333 \text{ N}} \end{cases}$

6/69 The coefficient of static friction μs between the 100-kg body and the 15° wedge is 0.20. Determine the magnitude of the force P required to begin raising
the 100-kg body if (a) rollers of negligible friction are present under the wedge, as illustrated, and (b) the rollers are removed and the coefficient of static friction μs= 0.20 applies at this surface as well.





Friction angle $\varphi = \tan^{-1}(0.20) = 11.31°$

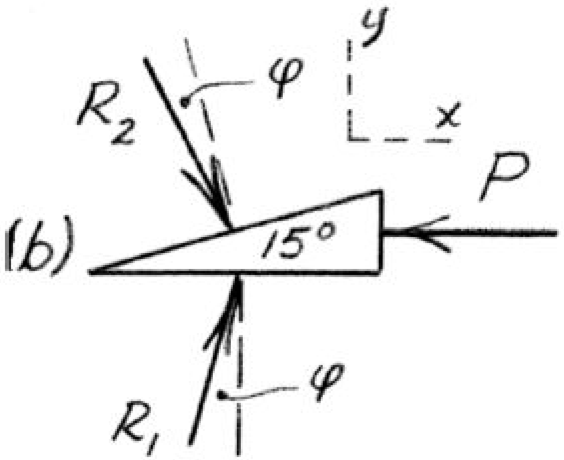
(a) Rollers under wedge:

$$\Sigma F_y = 0: \; -981 + R_2 \cos(15° + 11.31°) = 0$$

$$R_2 = 1094 \text{ N}$$

$$\Sigma F_x = 0: \; R_2 \sin(15° + 11.31°) - P = 0$$

$$\underline{P = 485 \text{ N}}$$



(b) Rollers removed:

Value of R_2 from 100-kg body is unchanged.

$$\Sigma F_x = 0: R_2 \sin(15° + 11.31°) - P + R_1 \sin(11.31°) = 0$$

With R_1 determined from overall equilibrium as $R_1 = 981/\cos 11.31° = 1000$ N, we solve for P as

$$\underline{P = 681\ \text{N}}$$

THANK YOU