K J SOMAIYA COLLEGE OF ENGINEERING, MUMBAI-77
(CONSTITUENT COLLEGE OF SOMAIYA VIDYAVIHAR UNIVERSITY)

Module 4.3 : Friction

Presented by:

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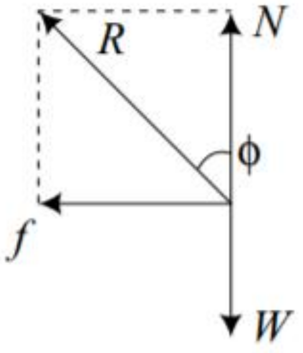
4.3 Friction

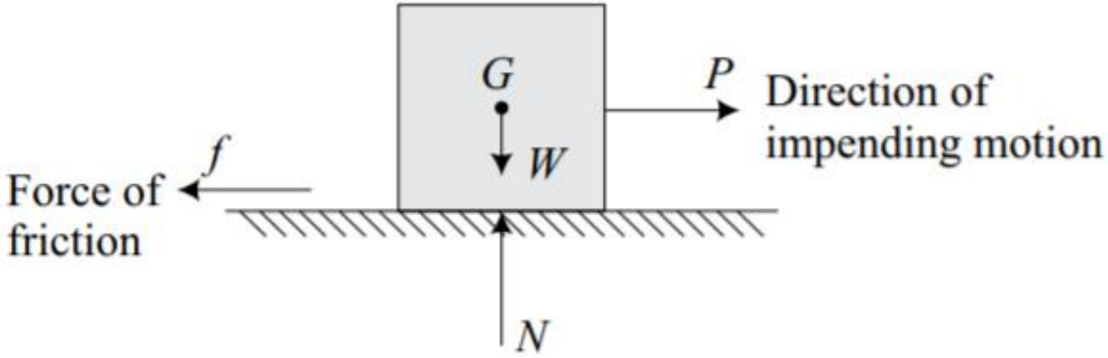
Laws of friction, cone of friction, angle of repose, equilibrium of bodies on inclined plane, application to problems involving wedges and ladders

What is friction?

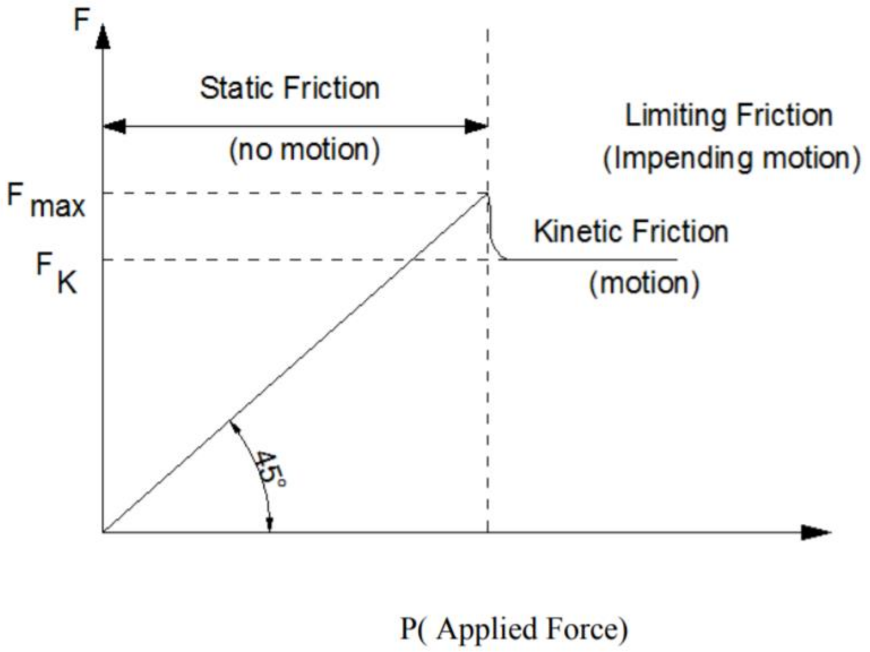
- ✓ **Definition:** Friction is defined as the contact resistance exerted by one body upon a second body when the second body moves or tends to move past the first body.
- ✓ Friction is a retarding force that opposes motion.
- ✓ Friction types:
  - ❑ Static friction
  - ❑ Kinetic friction
  - ❑ Fluid friction

Mechanism of Friction:





W = Weight of the body (mg)
N = Normal reaction
f = Friction force
P = Force applied to the body
R = Total reaction
ϕ = Angle of friction



"Limiting friction is the maximum value of friction force that the surface can exert on the block and is designated as F_{max}."

Angle of Friction

It is the angle made by the resultant (R) of the normal reaction (N) and limiting force of friction (f) and made with the direction of normal reaction.

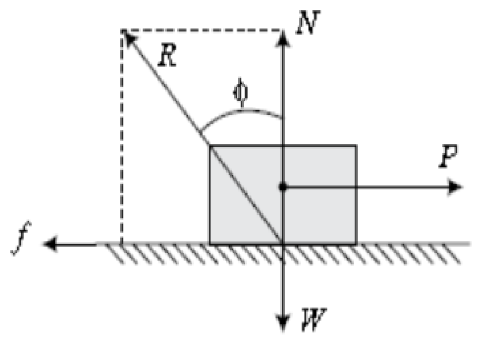
R is the resultant of normal reaction N and force of friction f.

$$R = \sqrt{N^2 + f^2}$$

ϕ is the angle of friction

$$\tan \phi = \frac{f}{N}$$

or $$\phi = \tan^{-1} \frac{f}{N}$$



Angle of friction

Coefficient of friction

It is ratio of limiting frictional force and the normal reaction.

The coefficient of friction,

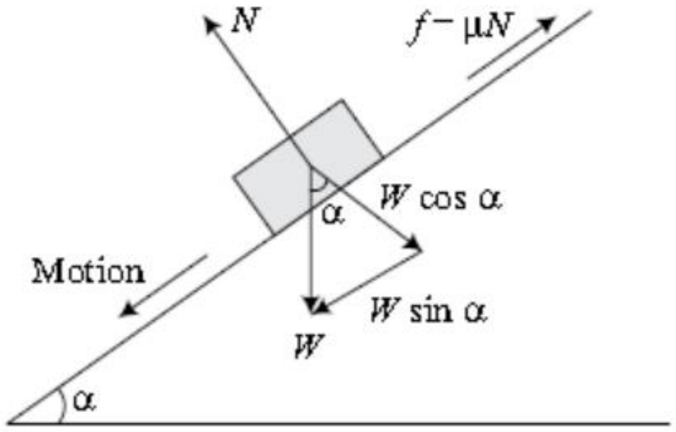
$$\mu = \frac{f}{N} = \tan \phi$$

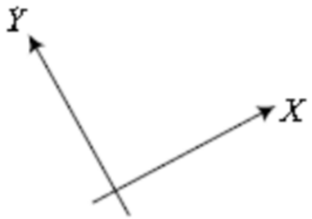
$$\therefore \quad f = \mu N$$

Table 8.1. Approximate Values of Coefficient of Static Friction for Dry Surfaces

Metal on metal	0.15–0.60
Metal on wood	0.20–0.60
Metal on stone	0.30–0.70
Metal on leather	0.30–0.60
Wood on wood	0.25–0.50
Wood on leather	0.25–0.50
Stone on stone	0.40–0.70
Earth on earth	0.20–1.00
Rubber on concrete	0.60–0.90

Angle of repose





Applying equilibrium conditions,

$$\Sigma F_X = 0$$

$$f = W \sin \alpha$$

$$\Sigma F_Y = 0$$

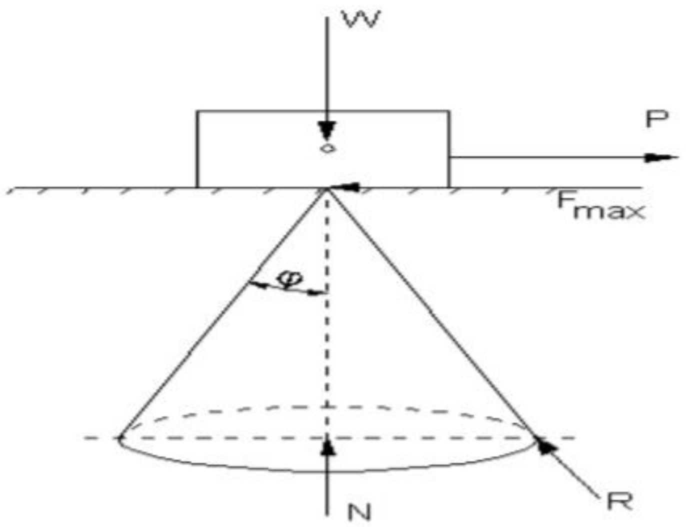
$$N = W \cos \alpha$$

$$\therefore \quad \frac{f}{N} = \frac{W \sin \alpha}{W \cos \alpha} = \tan \alpha$$

But, $$\frac{f}{N} = \mu = \tan \phi$$

where ϕ is called the angle of friction.

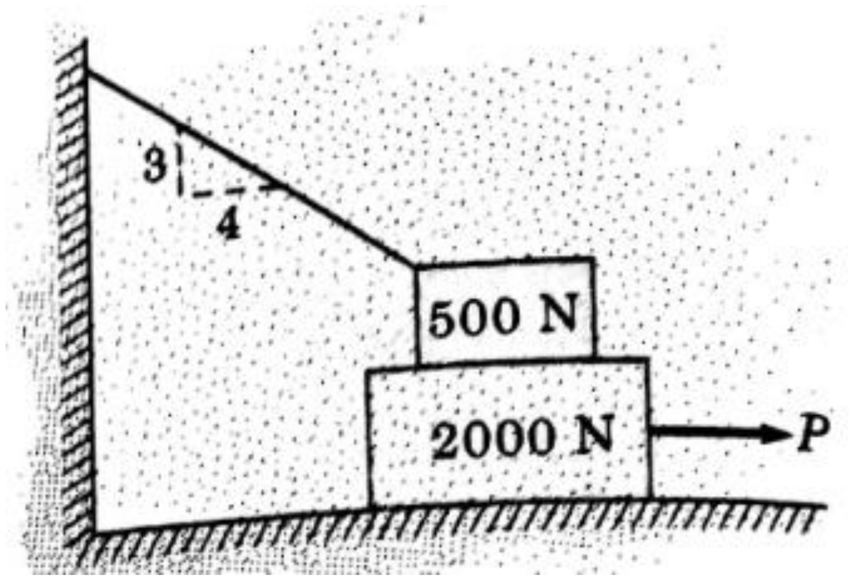
Cone of Friction:



- When the applied force P is just sufficient to produce the impending motion of given body, angle of friction ø is obtained which is the angle made by resultant of limiting frictional force with normal reaction as shown in Fig.
- If the direction of applied force P is gradually changed through 360^0, the resultant R generates a right circular cone with semi vertex angle equal to ø.
- This is called Cone of Friction.

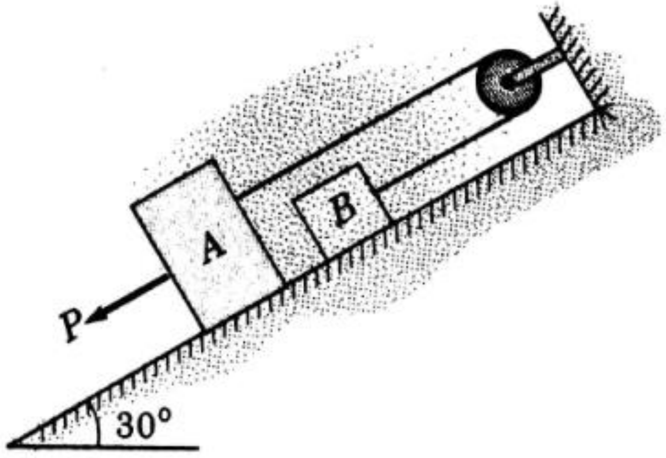
Problem No. 1

- A block weighing 500N is resting on another block of 2000N weight. The upper block is tied to a vertical wall by a wire. Determine the horizontal force P required to pull the lower block. The coefficient of friction between all surfaces of contact is 0.3.



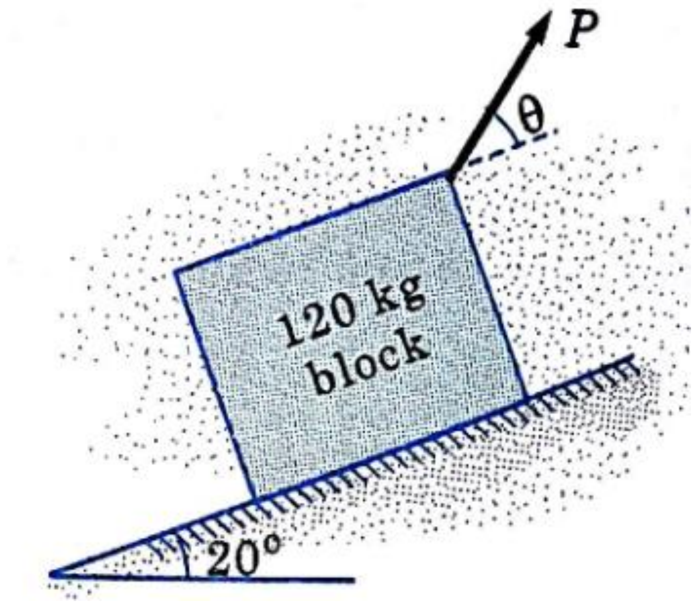
Problem No. 2

- Determine the force P to cause motion to impend. Take masses of A and B as 9 Kg and 4 Kg respectively and coefficient of friction as 0.25. The force P and rope are parallel to the inclined plane.



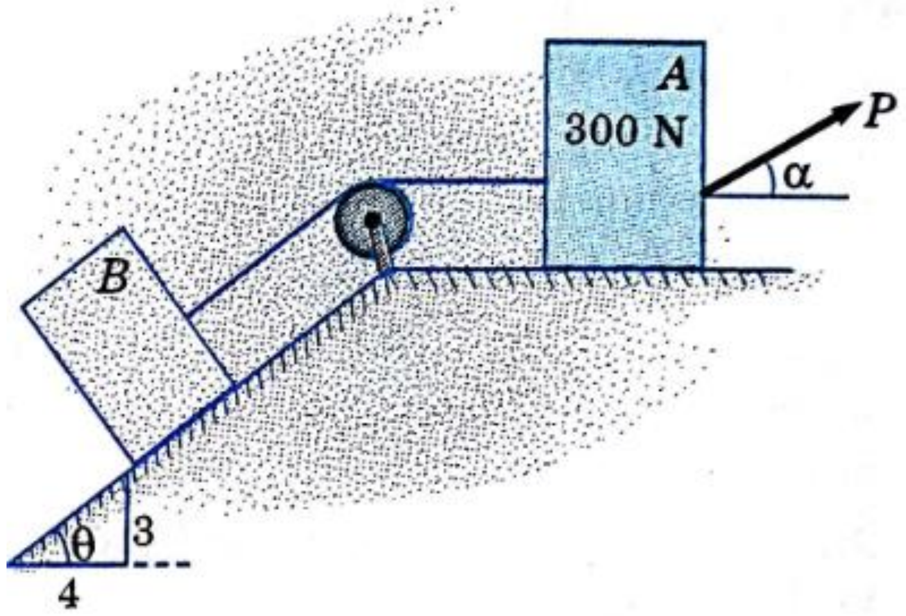
Problem No. 3

- Specify the angle ϴ and the magnitude P of the smallest force needed to tow the 120Kg crate up the incline. The coefficient of friction between the plane and the crate is 0.5.



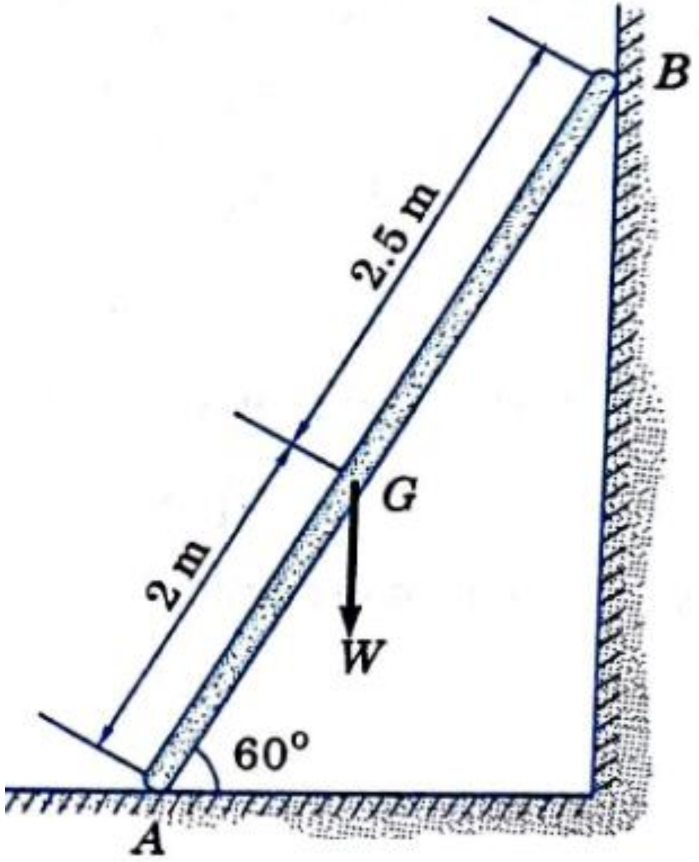
Problem No. 4

- Find the least force P that will just start the system of blocks moving to the right. Take μ = 0.3. Assume smooth pulley.



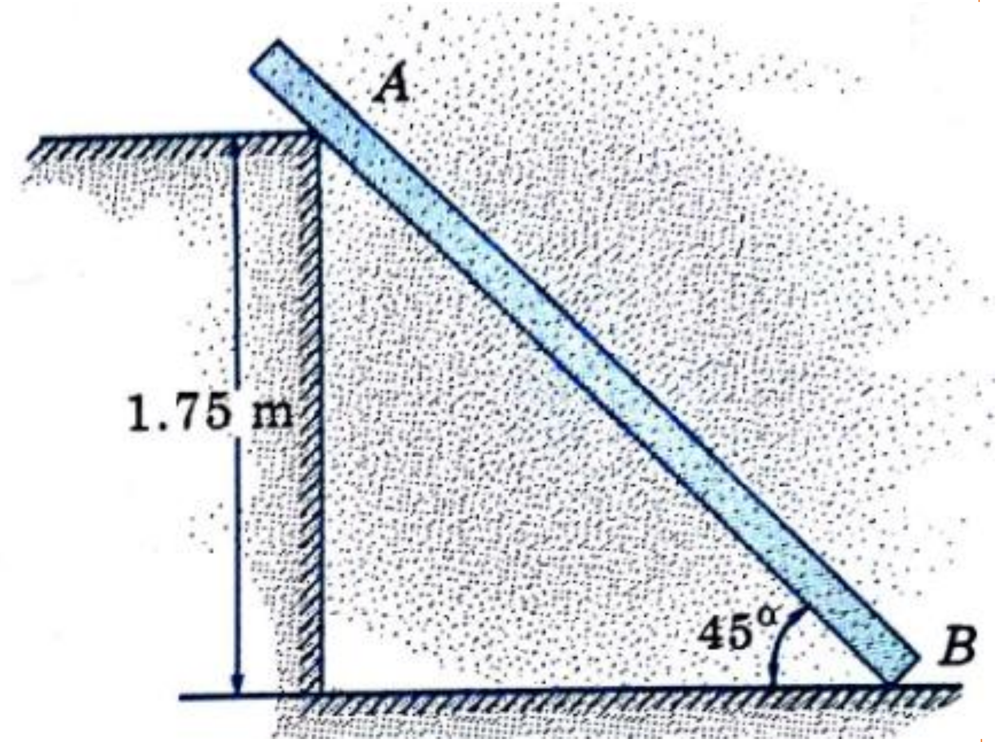
Problem No. 5

- A nonhomogeneous ladder shown in figure rests against a smooth wall at A and a rough horizontal floor at B. The mass of the ladder is 30Kg and is concentrated at 2m from the bottom. The coefficient of static friction between the ladder and the floor is 0.35. Will the ladder stand in position?



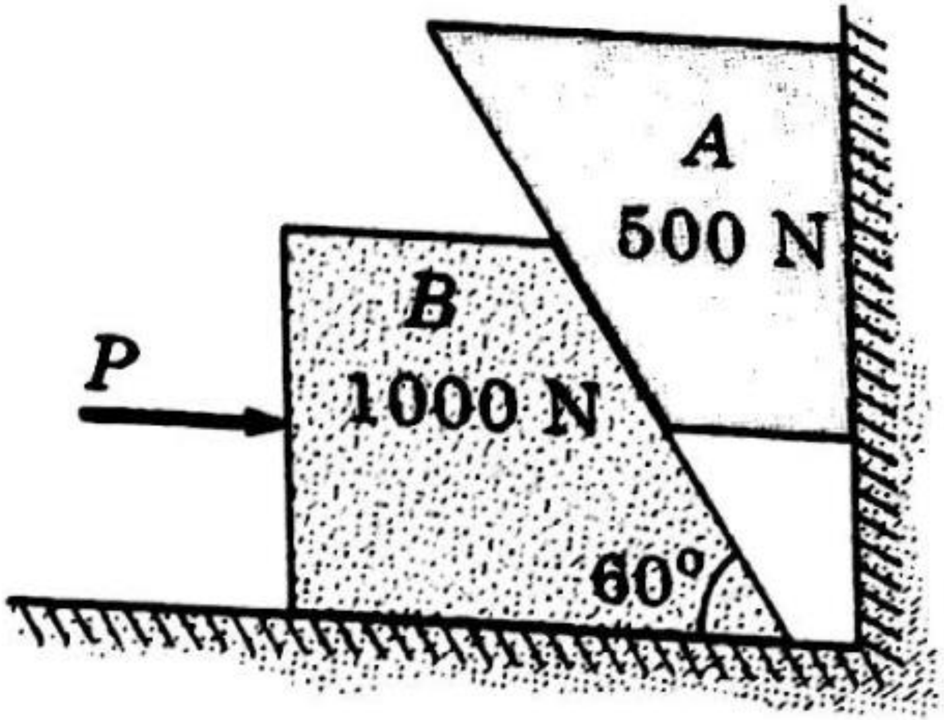
Problem No. 6

- Determine the minimum value of coefficient of coefficient of friction so as to maintain the position shown in figure. Length of rod AB is 3.5m and weighs 250N.



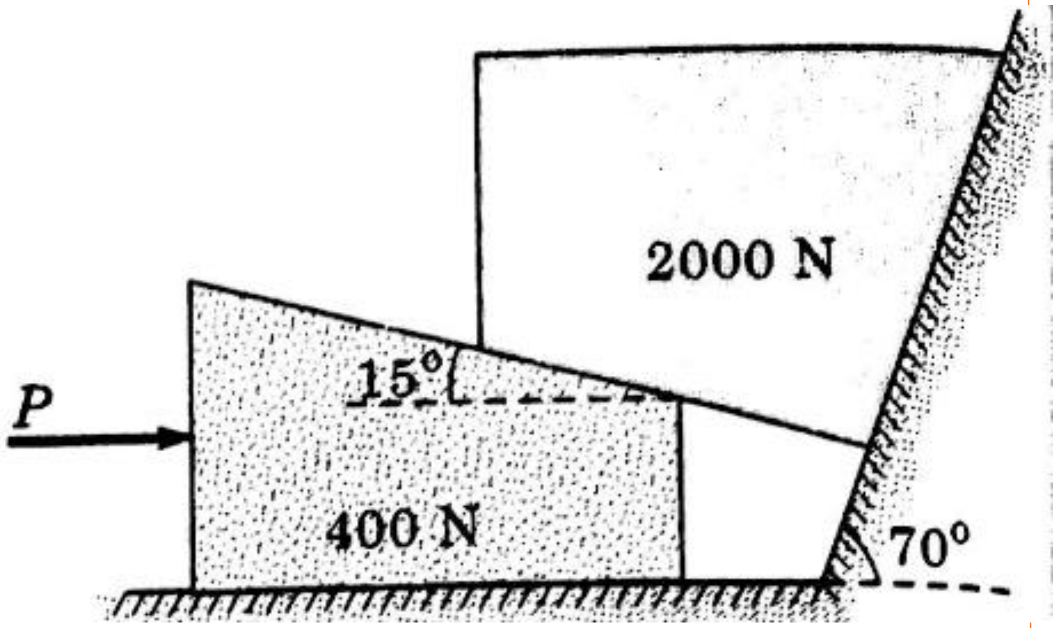
Problem No. 7

- Assuming the values for μ=0.25 at the floor and 0.3 at the wall and 0.2 between the blocks, find the minimum value of a horizontal force P applied to the lower block that will hold the system in equilibrium.



Problem No. 8

- Determine the horizontal force P shown in figure to start the 400N wedge moving to the right. Take angle of friction for all contact surfaces to be 20º.



Problem No. 9

- Three blocks are placed on the surface one above the other as shown in figure. The static coefficient of friction between the blocks and block C and the surface is also shown. Determine the maximum value of P that can be applied before any slipping takes place.