Al-Mustaqbal University
College of Engineering and Technologies
Prosthetics and Orthotics Engineering

MECHANICS-DYNAMIC TUTORIAL

Friction Force

Lec.1

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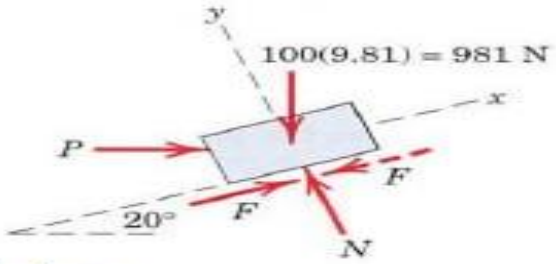
Friction Force- Tutorial

Determine the magnitude and direction of the friction force acting on the *100 kg* block shown if, first, $P = 500\ N$ and, second, $P = 100\ N$. the coefficient of static friction is *0.2*, and the coefficient of kinetic friction is *0.17*. the forces are applied with block initially at rest.

Solution:

There is no way of telling from the statement of the problem whether the block will remain in equilibrium or whether it will begin to slip following the application of *P*. it is therefore necessary to make an assumption, which take the friction force to be up the plane, as shown by the solid arrow.

$$\sum F_x = 0 \qquad P\cos 20° + F - 981\sin 20° = 0 \quad \ldots.(1)$$
$$\sum F_y = 0 \qquad N - P\sin 20° - 981\cos 20° = 0 \quad \ldots..(2)$$



Case I. $P = 500\ N$

Substitution *P* in equation 1 and 2.

$$F = -134.3\ N$$

The negative sign refers to if the block in equilibrium, the friction force acting on it is in the direction opposite to that assumed and therefore is down the plane, as represented by the dashed arrow.

$$from\ equation\ (2) \qquad N = 1093\ N$$

The maximum static friction force which the surface can support is;

$$F_{max} = \mu_s N = 0.2(1093) = 219\ N$$

Since this force is greater than that required for equilibrium, therefore the block remain at rest and the friction force is directed down the plane.

$$F = 134.3\ N\ (down\ the\ plane)$$

Case II. $P = 100\ N$

Form substitution P in equation 1 and 2 of equilibrium.

$$F = 242\ N \quad and \quad N = 956\ N$$

But the maximum possible static friction force is;

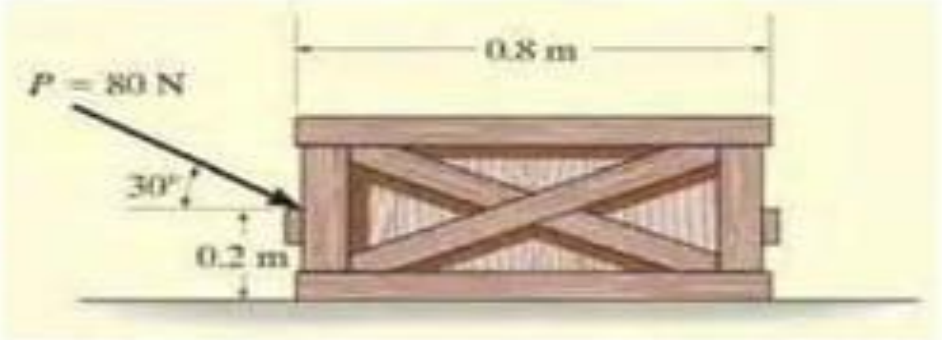
$$F_{max} = \mu_s N = 0.2(956) = 191.2\ N$$

Since the maximum possible static friction force is less than that required for equilibrium, therefore the block is slip down the plane and the correct value of friction force is obtain by using the kinetic coefficient of friction.

$$F_k = \mu_k N = 0.17(956) = 162.5\ N\ (up\ the\ plane)$$

Friction Force- Tutorial

The uniform crate shown in the figure has a mass of *20 kg*. if a force $P = 80\ N$ is applied to the crate, determine the friction force and its location if it remains in equilibrium. The coefficient of static friction is $\mu_s = 0.3$.



Solution:

Free – Body Diagram.

The resultant normal force N_C must act at a distance x from the crate's center line in order to counteract the tipping effect caused by P.

Equations of Equilibrium.

$$\overset{+}{\rightarrow} \sum F_x = 0 \qquad 80\cos 30° - F = 0 \qquad \therefore F = 69.3\ N$$

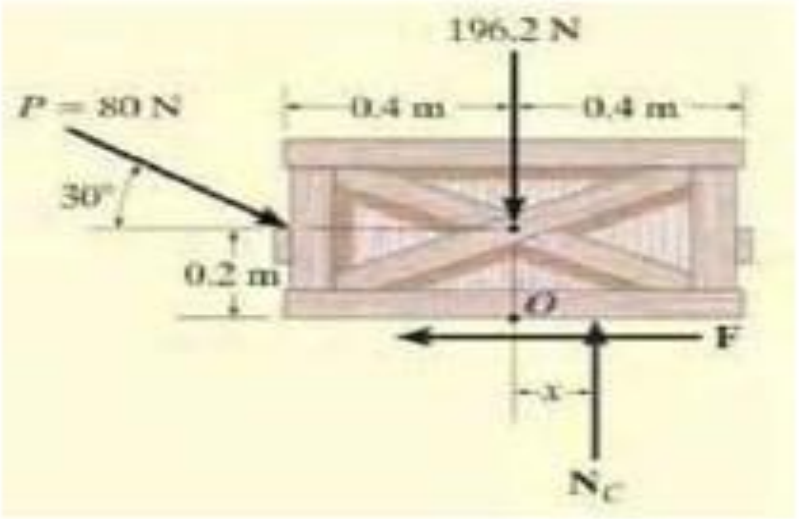
$$+\uparrow \sum F_y = 0 \qquad N_C - 196.2 - 80\sin 30° = 0$$

$$N_C = 236\ N$$

$$\sum M_O = 0$$

$$-80\cos 30°\,(0.2) + 80\sin 30°\,(0.4) + N_C(x) = 0$$

$$\therefore x = -0.00908\ m = -9.08\ mm$$

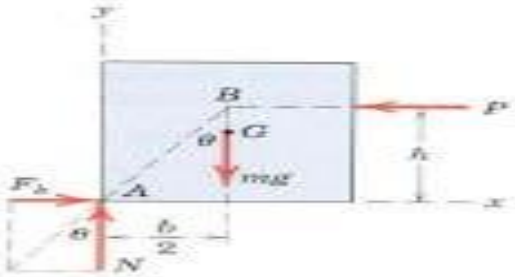


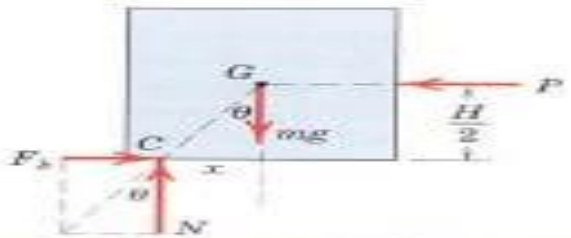
Friction Force- Tutorial

Example 4.5

The homogeneous rectangular block of mass m, width b, and height H is placed on the horizontal surface and subjected to a horizontal force P which moves the block along the surface with a constant velocity. The coefficient of kinetic friction between the block and the surface is μ_k. Determine **(a)** the greatest value which h may have so that the block will slide without tipping over and **(b)** the location of a point C on the bottom face of the block through which the resultant of the friction and normal forces acts if $h = H/2$.

Solution:





(a) With the block on the verge of tipping

$$\tan\theta = \mu_k = \frac{b/2}{h} \qquad \therefore h = \frac{b}{2\mu_k}$$

If h were greater than this value, moment equilibrium about A would not be satisfied, and the block would tip over.

Another method

$$\sum F_y = 0 \qquad N - mg = 0 \qquad \therefore N = mg$$

$$\sum F_x = 0 \qquad F_k - P = 0 \qquad \therefore P = F_k = \mu_k N = \mu_k mg$$

$$\sum M_A = 0$$

$$Ph - mg\left(\frac{b}{2}\right) = 0 \qquad \therefore h = \frac{mgb}{2P} = \frac{mgb}{2\mu_k mg} = \frac{b}{2\mu_k}$$

(b) With $h = H/2$

$$\frac{x}{H/2} = \tan\theta = \mu_k \qquad \therefore x = \mu_k H/2$$

Friction Force- Tutorial

Ex 1/

Determine the magnitude and direction of the friction force acting on the 100 kg block shown if, first, P=500 N and, second, P= 100 N. the coefficient of static friction is 0.2, and the coefficient of kinetic friction is 0.17. the forces are applied with block initially at rest.

Ex 2/

The uniform crate shown in the figure has a mass of 20 kg. if a force P = 80 N is applied to the crate, determine the friction force and its location if it remains in equilibrium. The coefficient of static friction is 0.3

Ex 3/

The homogeneous rectangular block of mass m, width ô, andheight H is placed on the horizontal surface and subjected to a horizontal force P which moves the block along the surface with constant velocity. The coefficient of kinetic friction between the block and the surface is a,. Determine (a) the greatest value which h may have so that the block will slide without tippingover and (b) the location of a point C on the bottom face of theblock through which the resultant of the friction and normalforces acts if h = H/2 .

Thanks