

Friction

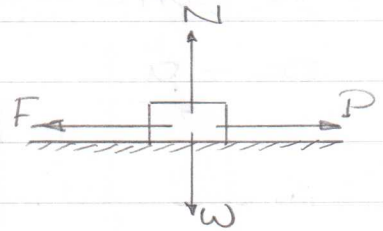
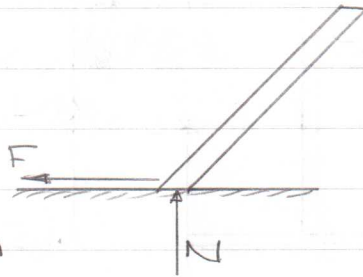
rough
friction

F is maximum

$$F_{\max} = \mu N$$

F is friction force

$$0 \leq F \leq \mu N$$



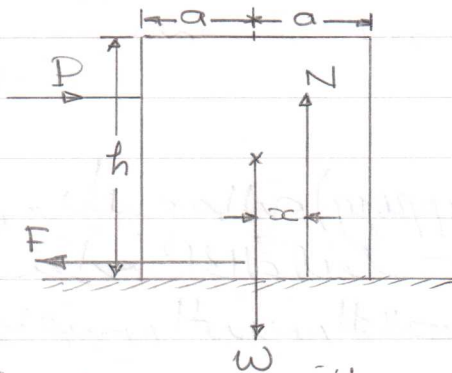
1. Slipping & Tipping:-

لقد التأثير على جسم موضوع على مستوى خشن بقوة (P) يحدث
أحد الحالتين الأربعة الآتية :-

① Stable مستقر

$$F < \mu N$$

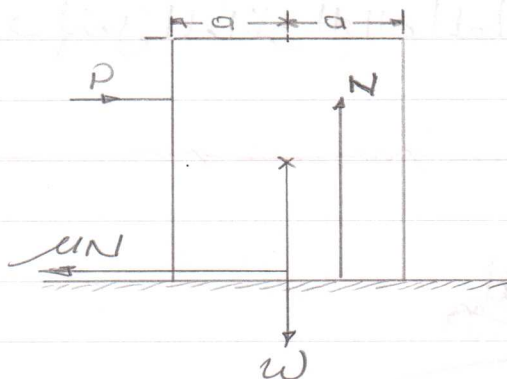
$$x < a$$



② Slipping without Tipping الانزلاق بدون انقلاب

$$F = \mu N$$

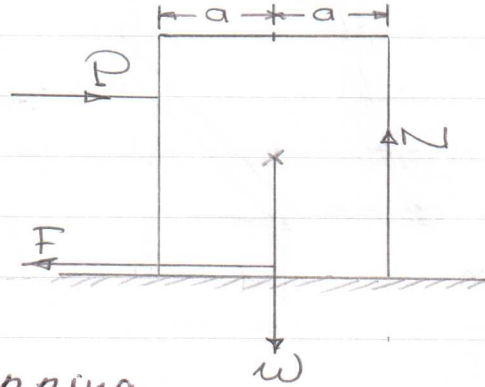
$$x < a$$



② Tipping without slipping

$$F < \mu N$$

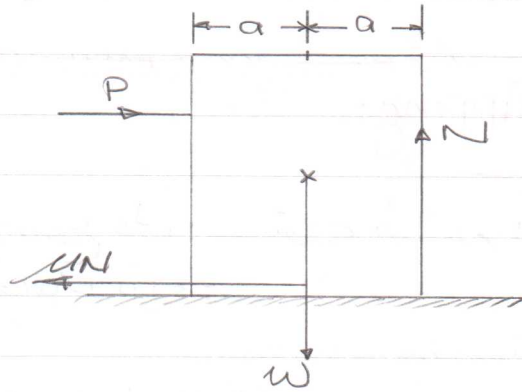
$$x = a$$



③ Tipping with slipping

$$F = \mu N$$

$$x = a$$



من التآزرية

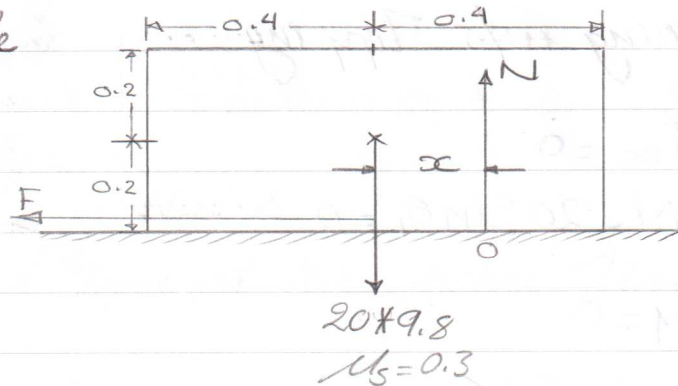
١- إذا أعطى بيانات الجسم وطلب حالة (Slipping or Tipping) ويتم ذلك بفرض استقارته "الحالة الأولى" و N و x و F و تم تحديد الشرط الرياضي المحدد للحالة.

٢- إذا أعطى حالة الجسم وطلب أحد بيانات الجسم المتبقية. ويتم ذلك بوضع ردود أفضل المفاظ للحالة المعطاة وكتابة معادلات التآزرية.

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To determine its state
assume that it is stable

$$\begin{aligned}\Sigma M_O &= \text{zero} \\ (196)(x) - 40\sqrt{3}(0.2) \\ + 40(0.4 + x) &= 0 \\ x &= -0.00908\end{aligned}$$



$$\begin{aligned}\Sigma F_x &= 0 \\ 40\sqrt{3} - F &= \text{zero} \\ F &= 69.3 \text{ N}\end{aligned}$$

$$\begin{aligned}\Sigma F_y &= 0 \\ N - 40 - 196 &= 0 \\ N &= 236 \\ \mu N &= 236 \times 0.3 = 70.8\end{aligned}$$

It's clear that:

$$\begin{aligned}x &< a \\ F &< \mu N\end{aligned}$$

∴ The Crate is in equilibrium.

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to get θ_1

* Slipping w/o Tipping

$$\Sigma F_x = 0$$

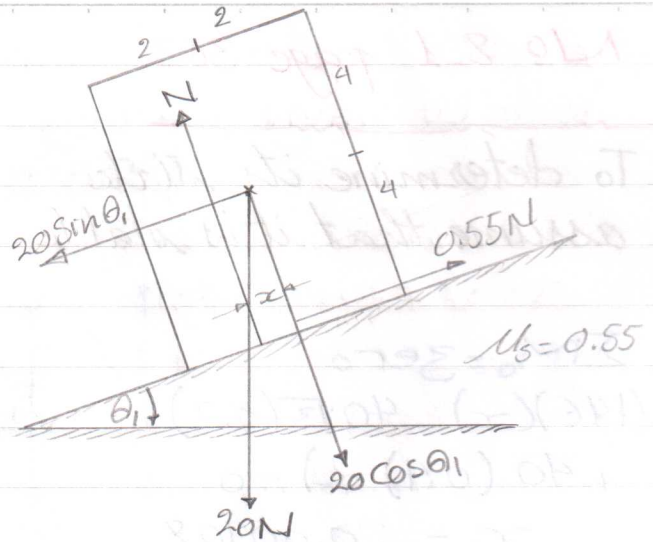
$$0.55N - 20 \sin \theta_1 = 0$$

$$\Sigma F_y = 0$$

$$N = 20 \cos \theta_1$$

$$0.55(20 \cos \theta_1) = 20 \sin \theta_1$$

$$\theta_1 = 28.8$$

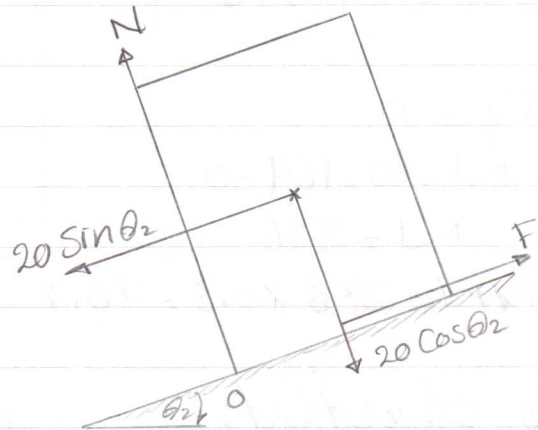


* Tipping w/o slipping

$$\Sigma M_o = \text{zero}$$

$$20 \sin \theta_2 (4) - 20 \cos \theta_2 (2) = 0$$

$$\theta_2 = 26.6$$

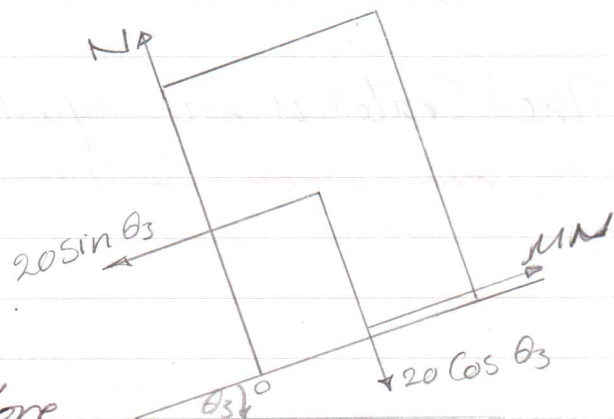


* Slipping with tipping

$$\Sigma M_o = \text{zero}$$

$$20 \sin \theta_3 (4) - 20 \cos \theta_3 (2) = \text{zero}$$

$$\theta_3 = 26.6$$



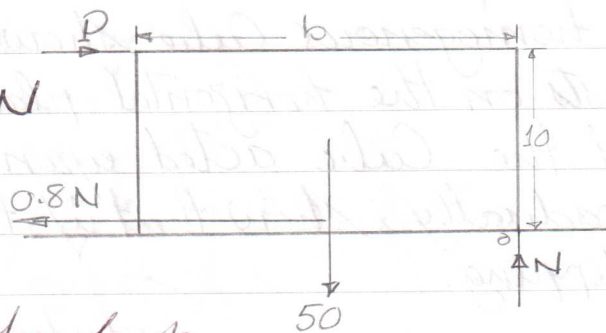
∴ The largest angle θ before the block moves = 26.6°

Example 8

The homogeneous block shown in figure has a weight of 50 N and rests on the floor, for which $\mu_s = 0.8$.

As P increase gradually.

Determine the width b of the block such that it slips and tips at the same time.



Sol.

$$\Sigma F_y = \text{zero}$$

$$N = 50$$

$$\Sigma F_x = \text{zero}$$

$$P = \mu N = 40$$

$$\Sigma M_o = \text{zero}$$

$$50(b/2) - P(10) = 0$$

$$25b = 400$$

$$b = 16$$



Examples

A homogenous Cube shown in figure weights w and rests on the horizontal plane ($\mu_s = 0.7$)

If the Cube acted upon by the force P which increases gradually, show that if the Cube Starts slipping or tipping.

Solution

Assume the block start slipping w/o tipping to get P_1 .

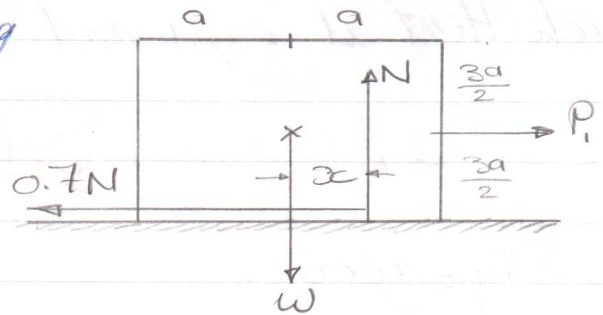
$$\sum F_x = 0$$

$$P_1 = 0.7N$$

$$\sum F_y = 0$$

$$N = w$$

$$P_1 = 0.7w$$



Assume the block starts tipping w/o slipping to get P_2

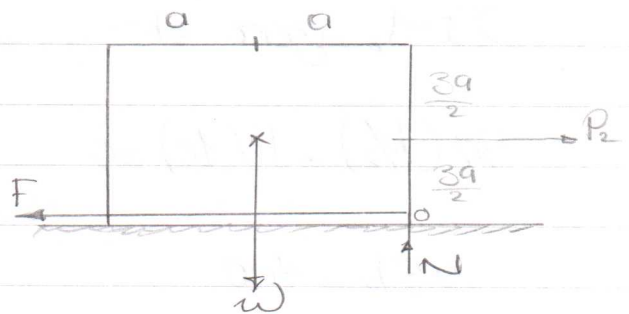
$$\sum M_o = 0$$

$$-P_2\left(\frac{3a}{2}\right) + w \times a = 0$$

$$P_2 = \frac{2}{3}w$$

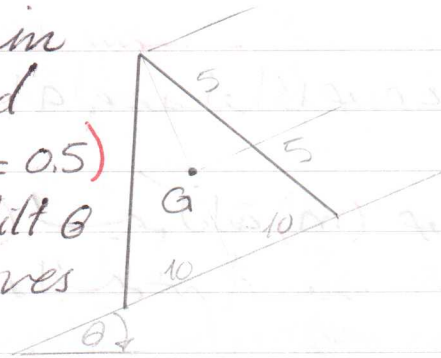
$$P_2 < P_1$$

∴ the block starts tipping.



Example.

the homogenous right cone shown in figure has a weight of 100N and rests on the incline $\mu_s = 0.5$. Determine the largest angle of tilt θ of the plane before the cone moves



Sol.

Assume slipping w/o Tipping to get θ_1

$$\sum F_x = 0$$

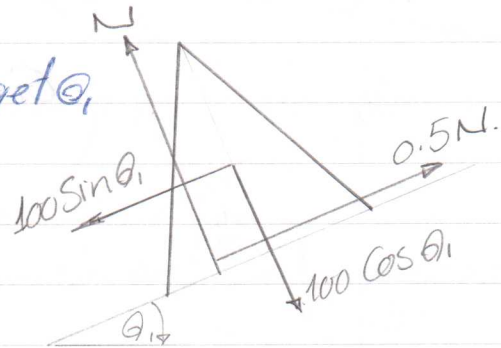
$$0.5N - 100 \sin \theta_1$$

$$\sum F_y = 0$$

$$N = 100 \cos \theta_1$$

$$\therefore 0.5 \times 100 \cos \theta_1 = 100 \sin \theta_1$$

$$\theta_1 = 26.6^\circ$$



Assume Tipping w/o Slipping to get θ_2

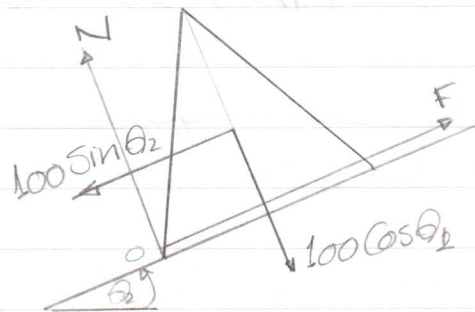
$$\sum M_o = \text{zero}$$

$$100 \sin \theta_2 \times 5 - 100 \cos \theta_2 (10) = 0$$

$$\tan \theta_2 = 2$$

$$\theta_2 = 63.4$$

$$\theta_1 < \theta_2$$



$\therefore$ The Largest angle of tilt before the Cone moves = 26.6