(Chapter - 6)

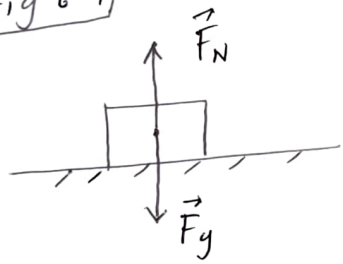
"Force and Motion - II"

Friction

When a force $\vec{F}$ tends to slide a body along a surface, a frictional force from the surface acts on the body. The frictional force is parallel to the surface and directed so as to oppose the sliding.

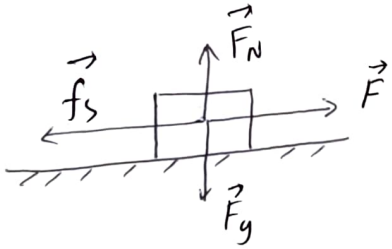
see - Fig 6-1

(a)



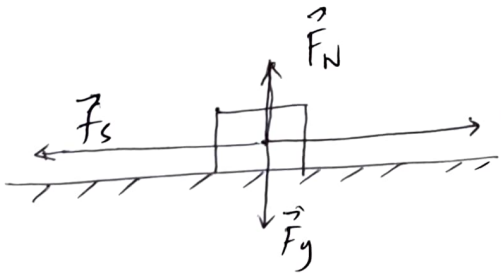
For no motion, and No applied Force → then → Frictional Force = 0

(b)



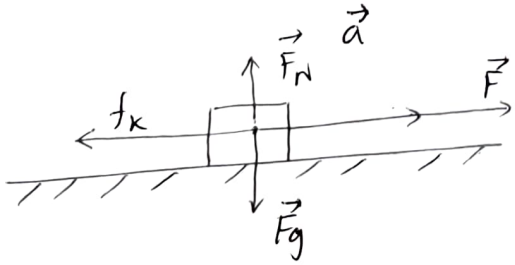
For applied force, F and No motion → then → Magnitude of Frictional Force and applied Force are equal

(c)

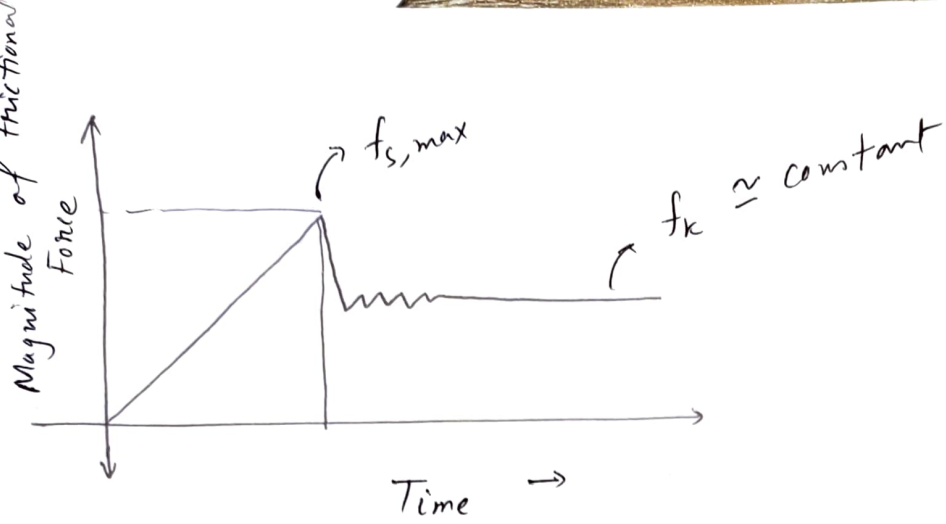


Now, applied Force increased but no motion → then → Magnitude of Frictional Force and applied Force are equal

(d)



applied Force is greater than maximum static Friction, then : has motion → then → Frictional Force, is kinetic Frictional Force



Two types of Friction,

i) Static Friction → when no motion

ii) kinetic Friction → when has motion

Maximum static friction, $\boxed{f_{s,max} = \mu_s F_N}$

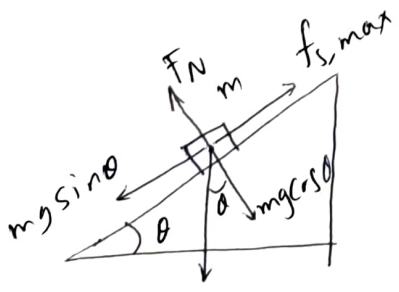
kinetic Friction, $\boxed{f_k = \mu_k F_N}$

μ_s = Static Friction co-efficient

μ_k = kinetic " "

F_N = Normal Force / Normal contact Force

$\boxed{\mu_s > \mu_k}$



$f_{s,max} = mg\sin\theta$ —(1)

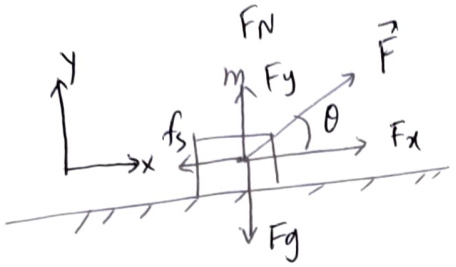
$f_{s,max} = \mu_s F_N = \mu_s\, mg\cos\theta$ —(2)

(1) and (2) $\Rightarrow$

$\therefore \mu_s\, mg\cos\theta = mg\sin\theta$

$\Rightarrow \boxed{\mu_s = \tan\theta}$

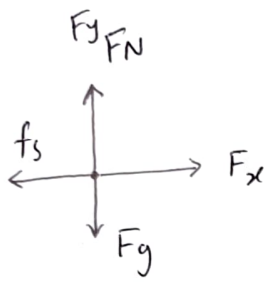
10



$F = 0.5mg$, $\theta = 20°$

$a = ?$

(a) $\mu_s = 0.6$, $\mu_k = 0.5$,



Applying Newton's 2nd law along y-axis,

$$F_y + F_N - F_y = m(0)$$

$$\Rightarrow F\sin\theta + F_N - mg = 0$$

$$\Rightarrow F_N = mg - F\sin\theta$$

$$= mg - 0.5mg\sin(20°)$$

$$\Rightarrow F_N = 0.83\,mg \quad \text{---(1)}$$

$$f_{s,max} = \mu_s F_N$$

$$= 0.6 \times 0.83mg$$

$$= 0.498\,mg$$

$$F_x = F\cos\theta = 0.5mg\cos(20°) = 0.47mg < f_{s,max}$$

So, $\boxed{a = 0}\ m/s^2$

(b) $\mu_s = 0.4$, $\mu_k = 0.3$, $a = ?$

In this case,

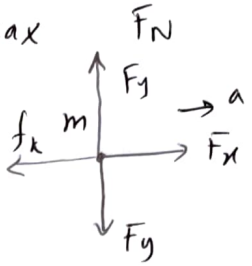
$$f_{s,max} = \mu_s F_N \qquad (F_N \text{ from eqn 1})$$

$$= 0.4 \times 0.83\,mg$$

$$= 0.332\,mg$$

$F_x = F\cos\theta = 0.5\, mg\cos(20^\circ)$

$= 0.47\, mg > f_{s,max}$



So, block will move.

Applying Newton's 2nd Law

at x-axis, $F_x - f_k = ma$

$$\Rightarrow a = \frac{F_x - f_k}{m}$$

$$= \left[\frac{0.47\, mg - \mu_k F_N}{m}\right] m/s^2$$

$$= \left[\frac{0.47\, mg - 0.3 \times 0.83}{m}\right] m/s^2$$

$$= \left[\frac{0.47\, mg - 0.25\, mg}{m}\right] m/s^2$$

$$= \frac{(0.47 - 0.25)\, mg}{m} \; m/s^2$$

$$= 0.221 \times 9.8 \; m/s^2$$

$$= \boxed{2.16\; m/s^2}$$

Chapter - 6

SP: 6.01, 6.02, 6.04, 6.05, 6.06

CP: 5, 10*, 16, 23*, 27, 47, 57*, 70, 88

CP: 1, 2