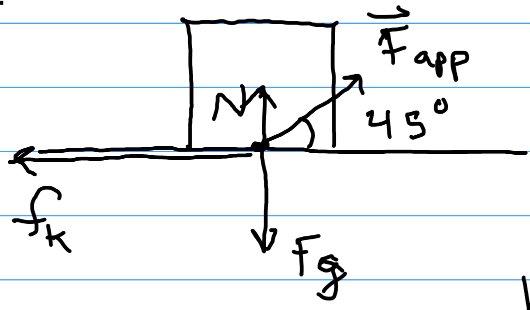
What is the acceleration of a 50 kg box on a horizontal surface if the applied force is = 50 i + 50 j Newtons and the box is sliding to the right?

Soln:



$$a_x = \frac{F_{net,x}}{m}$$

$$F_{net,x} = 50\hat{i} - f_k\,\hat{i}$$

but $f_k = \mu_k N$ and $N < mg$

find N

$$F_{net,y} = 0 = -mg\hat{j} + N\hat{j} + 50N\hat{j}$$

$$\therefore\ mg - 50 = N$$

$$50 \cdot 10 - 50 = N$$

$$450 = N$$

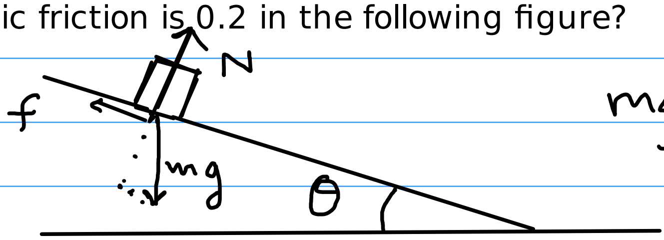
So $f_k = 0.2(450) = 90\,N$

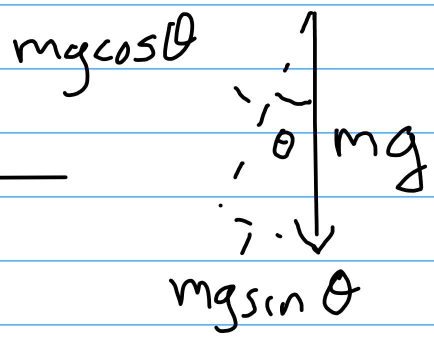
and $F_{net,x} = 50\hat{i} - 90\hat{i}\ N = -40\hat{i}\ N$

So $a_x = \dfrac{-40N}{50kg} = \boxed{-0.8\ m/s^2\ \hat{i}}$

Incline Example

What is the maximum inclination angle before slippage if the coefficient of static friction is 0.2 in the following figure?





Ans: slippage is when

$$f_s = f_{s,max} = \mu_s N = F_{g,x} = mg\sin\theta$$

Since $N = mg\cos\theta$,

$$f_s = \mu_s mg\cos\theta = mg\sin\theta$$

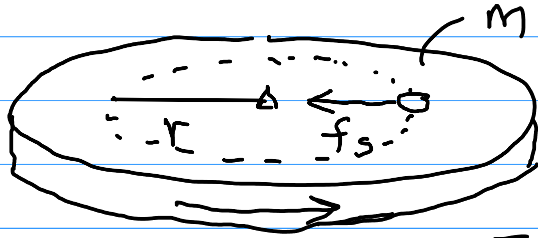
$$\therefore \quad \mu_s = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$\therefore \quad \theta = \tan^{-1}\mu_s = \tan^{-1}(0.2)$$

$$\boxed{\theta = 11.3^\circ}$$

Combine friction with circular motion:

Q: How far can a penny be placed from the center of a spinning, 78-rpm record before it slides off?



Soln: Slip occurs when $F_c = f_{s,max}$

$$F_c = m\frac{v^2}{r} \quad \text{and} \quad f_{s,max} = \mu_s mg$$

$$\cancel{m}\frac{v^2}{r} = \mu_s \cancel{m} g$$

Need v from rpm...

$$78\,\frac{rev}{min}\left(\frac{1\,min}{60\,sec}\right) = 1.3\,\frac{rev}{sec}$$

$$v = 1.3\,\frac{\cancel{rev}}{sec}\left(2\pi r\,\frac{m}{\cancel{rev}}\right) = 8.17r\ m/s$$

$$\therefore \frac{v^2}{r} = \frac{(8.17)^2 r^2}{r} = \mu_s g$$

$$r = \frac{\mu_s g}{(8.17)^2} = \frac{0.2(9.8)}{66.72} = 0.029\,m$$

$$\therefore \boxed{r = 2.9\,cm}$$