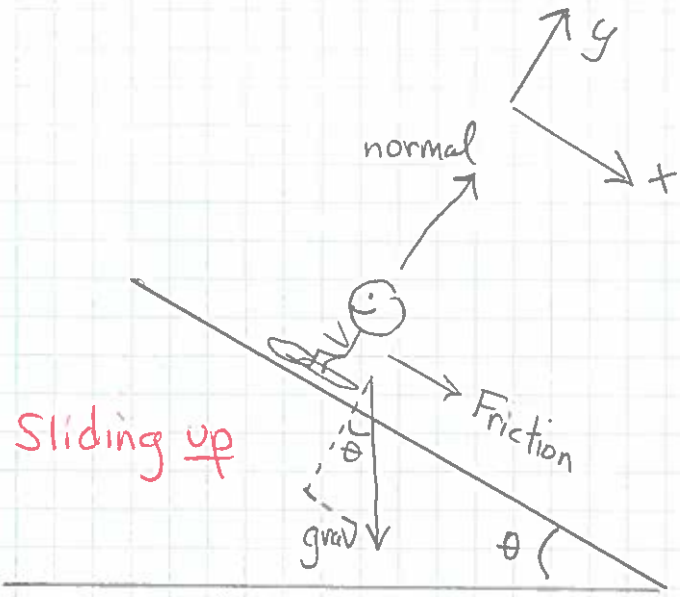
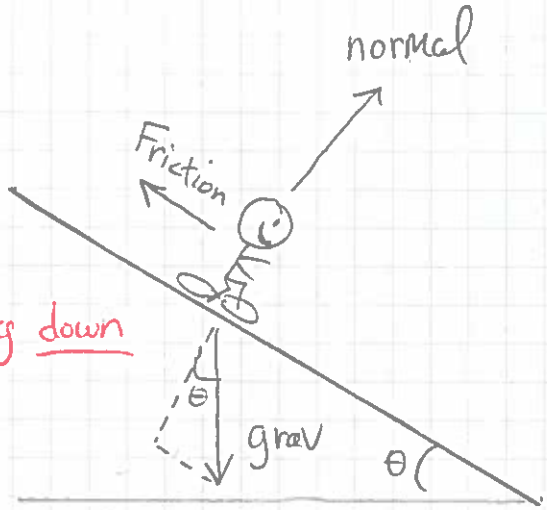


Sliding up



Sliding down

Usagi goes to the ski resort and finds a hill with angle $\theta = 11.8°$. The coefficient of kinetic friction between snow and skis is $\mu_K = 0.022$.

sliding up

force	x	y
gravity	$mg\sin\theta$	$-mg\cos\theta$
normal	0	$+F_N$
friction	$+\mu_K F_N$	0
	$+ma_x$	$ma_y = 0$

$$F_N = mg\cos\theta$$

$$ma_x = mg\sin\theta + \mu_K(mg\cos\theta)$$

$$ma_x = mg(\sin\theta + \mu_K\cos\theta)$$

$$a_x = g(\sin\theta + \mu_K\cos\theta)$$

sliding down

force	x	y
gravity	$mg\sin\theta$	$-mg\cos\theta$
normal	0	$+F_N$
friction	$-\mu_K F_N$	0
	$+ma_x$	$ma_y = 0$

$$F_N = mg\cos\theta$$

$$ma_x = mg\sin\theta - \mu_K(mg\cos\theta)$$

$$ma_x = mg(\sin\theta - \mu_K\cos\theta)$$

$$a_x = g(\sin\theta - \mu_K\cos\theta)$$

Note the difference in acceleration when sliding up vs. down.

The ski cannon shoots Usagi up the hill at an initial velocity of $v_i = 31.2\ m/s$. How far up does she slide?

Along slope is in $-x$ direction

$v_i = -31.2\ m/s$

$v_f = 0.0\ m/s$ when she stops sliding up

$a_x = g(\sin\theta + \mu_K \cos\theta) = 0.226\,g = -2.22\ m/s^2$

$$v_f^2 - v_i^2 = 2a_x(x_f - x_i)$$

$$(x_f - x_i) = \frac{(0.0\ m/s)^2 - (-31.2\ m/s)^2}{2(-2.22\ m/s^2)} = -220\ m$$

How long does it take to slide uphill this distance?

$$v_f = v_i + a_x t$$

$$t = \frac{v_f - v_i}{a_x} = \frac{(0.0\ m/s) - (-31.2\ m/s)}{(-2.22\ m/s^2)} = 14.1\ s$$

Now, after stopping momentarily, Usagi will slide back down to the bottom of the hill. It's the same distance, but now her acceleration is smaller in size. How long will it take to reach the bottom?

$$a_x = g(\sin\theta - \mu_K \cos\theta) = 0.183\,g = 1.79\ m/s^2$$

$$x_f = x_i + v_i t + \tfrac{1}{2} a_x t^2$$

$$0 = -220\ m + 0 + \tfrac{1}{2}(1.79\ m/s^2)\,t^2$$

$$220\ m = \tfrac{1}{2}(1.79\ m/s^2)\,t^2$$

$$\rightarrow t = \sqrt{\frac{2(220\ m)}{1.79\ m/s^2}} = 15.7\ s$$

takes longer than 14.1 s