Friction – dry / Coulomb friction

(A) Slipping

1. relative motion $v \neq 0$ or $a \neq 0$
2. $F = \mu N$
3. $\hat{F}$ opposes motion ($\hat{v}$ or $\hat{a}$)

(B) Sticking

1. no relative motion $v = 0$, $a = 0$
2. $F \leq \mu N$

(C) Transition

$v = 0$, $a = 0$

$F = \mu N$

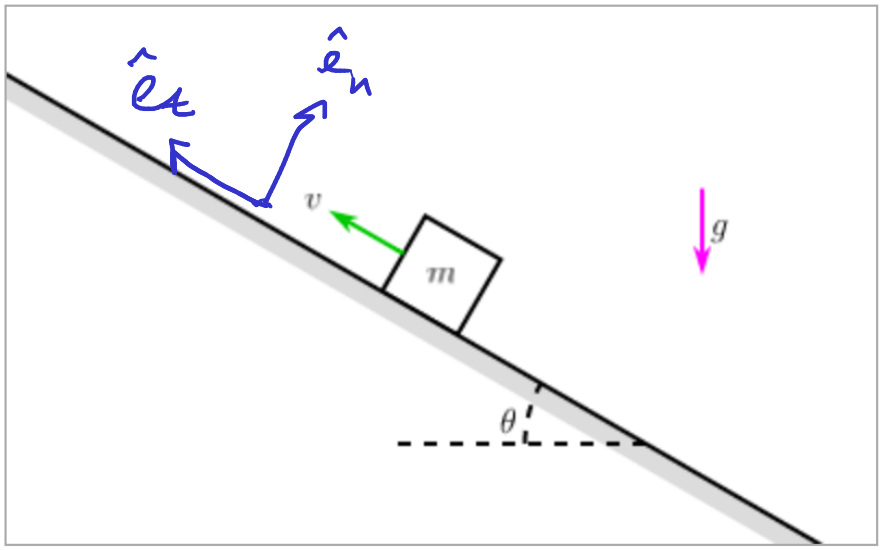
F = friction force

N = normal force

μ = coeff. friction.

#9-2. Acceleration of a block with friction (slopeFrictionAcc)

A block of mass $m = 8$ kg is sliding up a sloped ground with speed $v = 9$ m/s. The ground is at an angle of $\theta = 30^\circ$ from horizontal, the coefficient of friction between the block and ground is $\mu = 0.25$, and gravity $g = 9.8$ m/s^2 acts vertically.

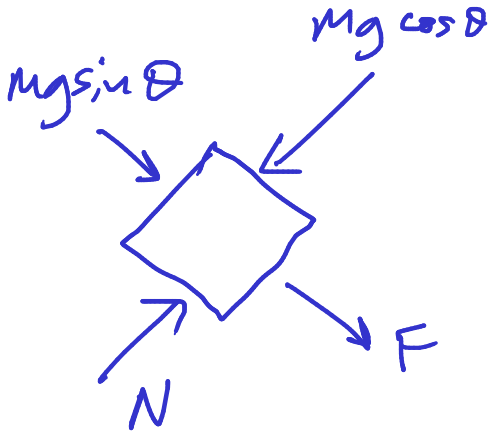


What is the acceleration $\vec{a}$ of the block?

$\vec{a} =$ [ ] $\hat{\imath} +$ [ ] $\hat{\jmath}$ m/s^2

$F = \mu N$

$\hat{F}$ opposes motion



* A. Slip
B. Stick
C. transition

* A. 1
B. 2
C. 3
D. 4
E. 5

$N = mg\cos\theta$

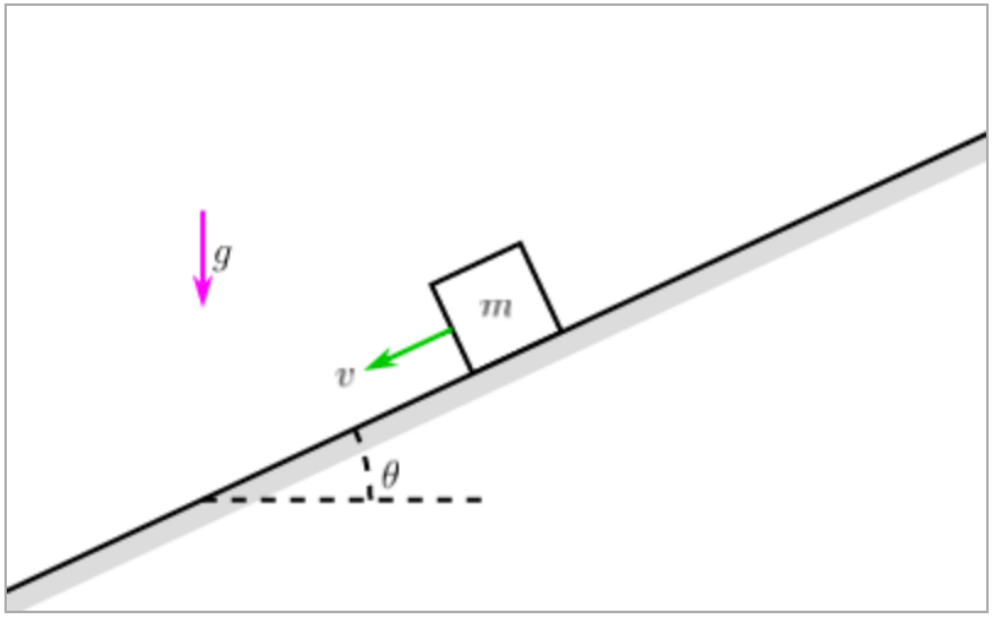
$\vec{a} = a_t \hat{e}_t$

F, N, a_t

A. $ma_t = F + mg\sin\theta$
B. $ma_t = -F + mg\sin\theta$
C. $ma_t = F - mg\sin\theta$
D. $ma_t = -F - mg\sin\theta$

#9-2. Acceleration of a block with friction (slopeFrictionAcc)

A block of mass $m = 8$ kg is sliding down a sloped ground with speed $v = 5$ m/s. The ground is at an angle of $\theta = 25^\circ$ from horizontal, the coefficient of friction between the block and ground is $\mu = 0.25$, and gravity $g = 9.8$ m/s^2 acts vertically.



What is the acceleration $\vec{a}$ of the block?

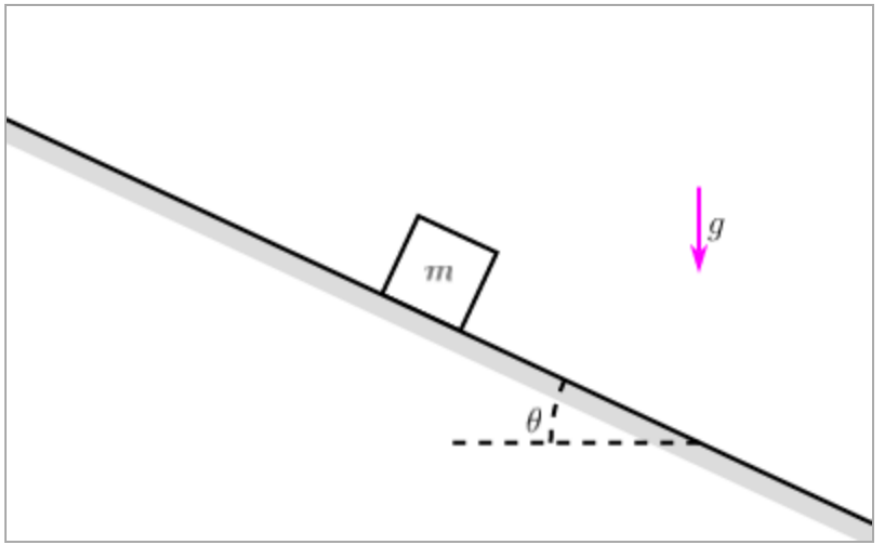
$\vec{a} =$ _____ $\hat{\imath} +$ _____ $\hat{\jmath}$ m/s^2

Given that $\vec{g}$ is down and $\vec{v}$ is down the slope:

A. $\vec{a}$ must be down the slope
B. $\vec{a}$ must be up the slope
C. $\vec{a}$ might be up or down the slope

#9-4. Minimum coefficient of friction on a slope (slopeFrictionMinCoeff)

A block of mass $m = 9$ kg starts at rest on a sloped ground. The ground is at an angle of $\theta = 25^\circ$ from horizontal and gravity $g = 9.8$ m/s^2 acts vertically.



What is the minimum coefficient of friction μ so that the block will not slide?

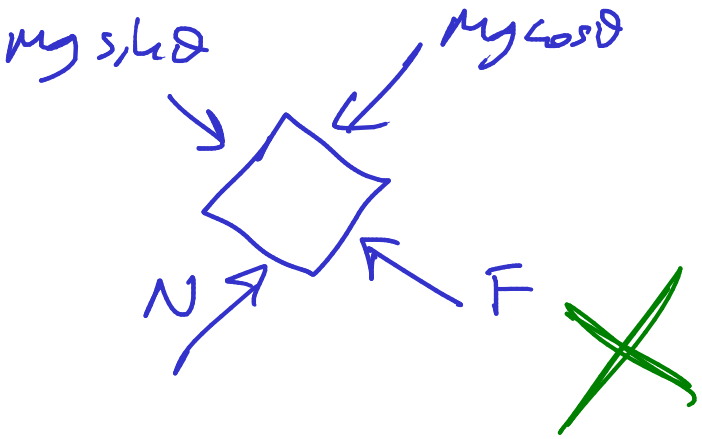
$\mu =$

A. Slip
B. Stick
C. Transition

$V = 0, a = 0$

$F = \mu N$

A. $F = \mu N$
B. $a = 0$
C. $v = 0$
D. $F \leq \mu N$
E. $a \leq 0$



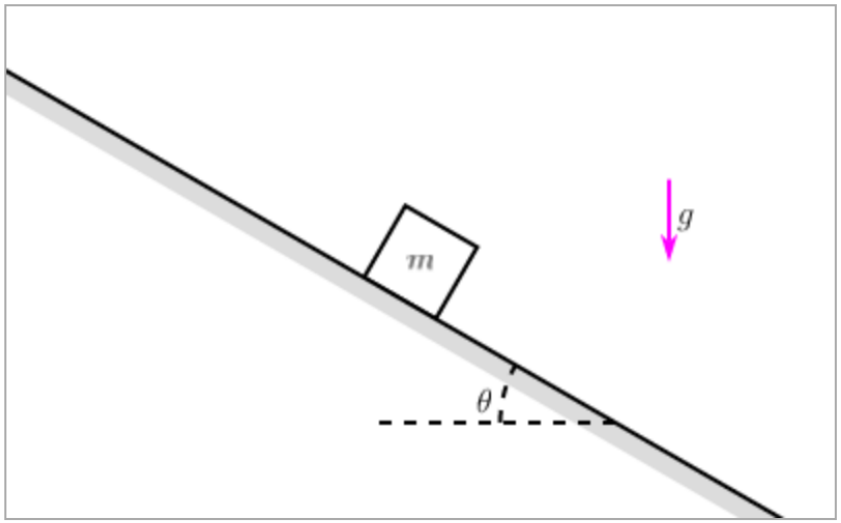
$\mu = \tan\theta$

μ depends on:

A. m, θ, g
B. m, θ
C. θ, g
D. m, g
E. θ

#9-9. Motion of a block with friction (slopeFrictionStick)

A block of mass $m = 3$ kg starts at rest on a sloped ground. The ground is at an angle of $\theta = 30^\circ$ from horizontal, the coefficient of friction between the block and ground is $\mu = 0.5$, and gravity $g = 9.8$ m/s^2 acts vertically.



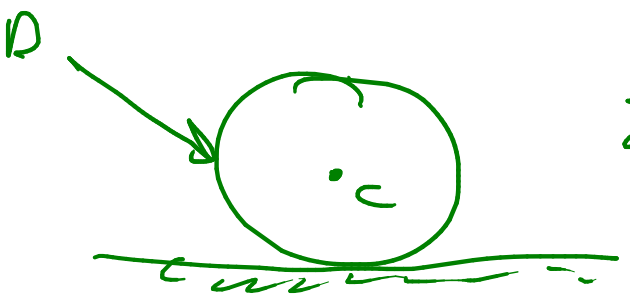
What type of motion does the block experience?

- The block sticks and does not move.
- The block slips and accelerates down the slope.

— stick.
— slip up.
— slip down.

How many scenarios are kinematically consistent?

A. 1
B. 2
C. 3
D. 4
E. 5

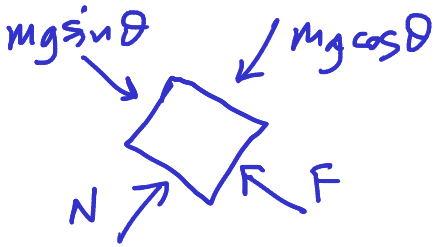


$\vec{a}_c$? slip? stick?

~~Stick~~

→ assumed motion

$a = 0$



check: $|F| \leq \mu|N|$ ✗

~~$F =$~~ $14.7\,N$

$N = 25.5\,N$

$\mu N = 12.75$

A. 10.3
B. 14.7
C. 17.2
D. 19.6

$m = 3\,kg$, $\theta = 30°$, $g = 9.8\,m/s^2$

$\mu = 0.5$

~~Slip up~~ $\vec{v}$ up

→ assumed force

$\vec{F} =$

check: $a \neq 0$

$\hat{F}$ opposes $\hat{a}$ ✗

$F = -12.74\,N$ up

$N = 25.5\,N$

→ $a = -9.15$ up m/s^2

A. 6.25
B. −9.8
C. −9.15
D. 10.24

Slip down ✓ $\vec{v}$ down

→ assumed force

$\vec{F} =$

check: $a \neq 0$ ✓

✓ $\hat{F}$ opposes $\hat{a}$

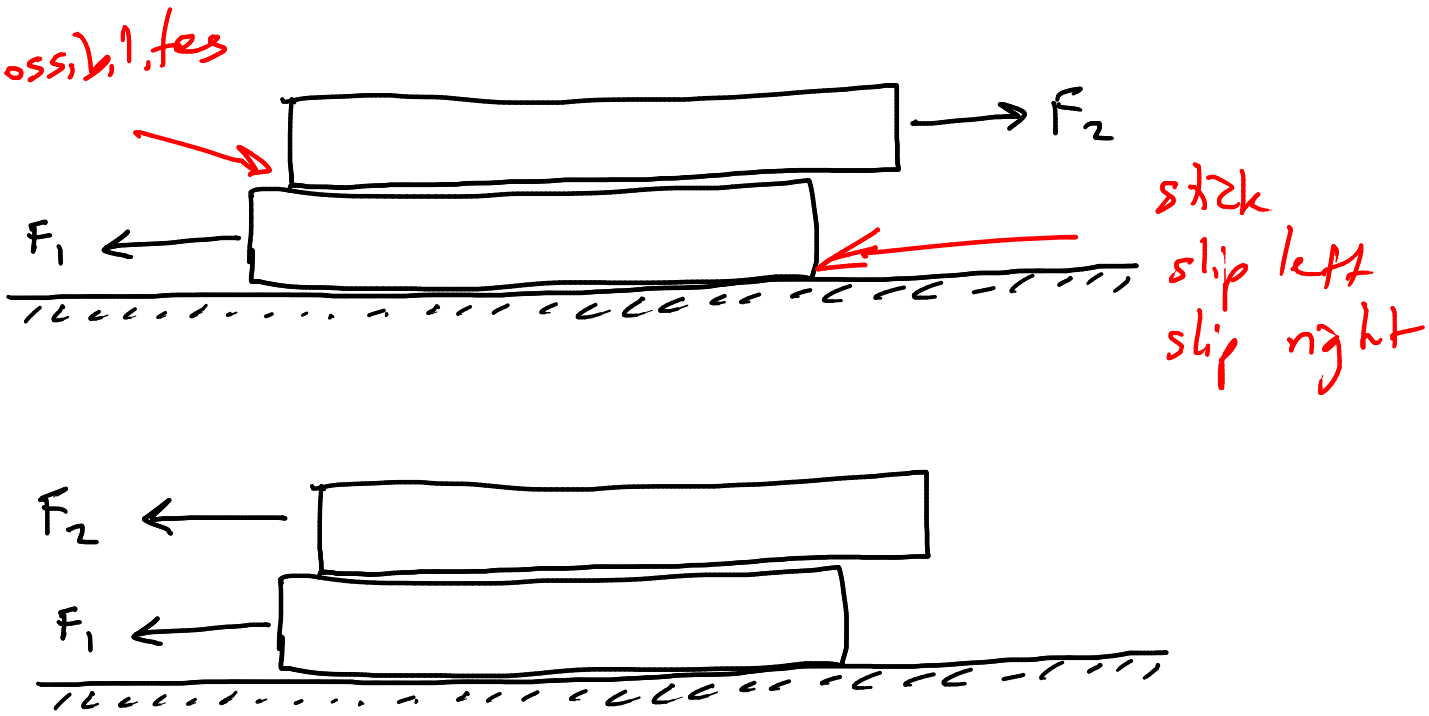
$F = 12.74\,N$ up

$N = 25.5\,N$

→ $a = -1.97$ up m/s^2

A. 12.14
B. −6.24
C. 4.19
D. −1.97

Ex



How many scenarios are kinematically consistent?

A. 2
B. 4
C. 9
D. 16
E. 25