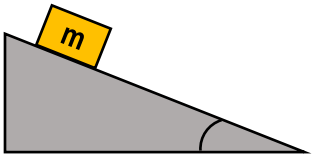
CONCEPT: SOLVING INCLINED PLANE PROBLEMS WITH FRICTION

- You'll need to solve problems with objects on inclined planes *WITH* friction**.**

  - Remember: To determine if objects begin moving, compare all non-friction forces ALONG the axis of motion to **____.**

EXAMPLE**:** You release a 10kg block on ramp inclined at 37°**.** The coefficients of friction are μ_s = 0.6 and μ_k = 0.4**.**
a) Calculate the friction force acting on the block when it is released**. b)** Calculate the block's acceleration**.**



INC. PLANES + FRICTION
1) Draw FBD (tilt x&y axes on inclines)
2) Determine if $\boldsymbol{f} = \boldsymbol{f_s}$ or $\boldsymbol{f_k}$ from text or: If ΣFs on axis of motion > $f_{s,max}$, $\boldsymbol{f} = \boldsymbol{f_k}$
3) Write $\boldsymbol{\Sigma F = ma}$
4) Solve

PROBLEM: You attempt to push a 20-kg box up a ramp into a moving truck, applying a 110-N force parallel to the incline. The ramp is angled at 15°. The coefficients of friction between the box and the ramp are μ_s=0.3 and μ_k=0.2. What are the magnitude and direction of the box's acceleration?

A) 0 m/s^2 (no direction)
B) 0.1 m/s^2 up the ramp
C) 1.1 m/s^2 up the ramp
D) 4.5 m/s^2 down the ramp

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● If the direction of $\boldsymbol{f}$ isn't known, find the net of all non-friction forces along axis of motion. $\boldsymbol{f}$ will be _____ to that.

PROBLEM: A 2.0-kg block is launched up 40° ramp at 10 m/s. If the block comes to a stop when it reaches a point 3 m vertically above the bottom of the ramp, calculate the coefficient of kinetic friction between the block and the ramp.

A) 0.45
B) 0.51
C) 0.59
D) 0.67

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PROBLEM**:** You push a 30kg mini-fridge up a 20° incline**.** Your push is 120N angled 30° ***above the axis of the incline*****.** If the coefficients of friction between the box and the ramp are μ_s=0.3 and μ_k=0.2, what is the box's acceleration?

A) 0 m/s^2 (no direction)
B) 0.1 m/s^2 up the ramp
C) 1.1 m/s^2 up the ramp
D) 4.5 m/s^2 down the ramp

INC. PLANES + FRICTION

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CONCEPT: CRITICAL ANGLES ON ROUGH INCLINED PLANES

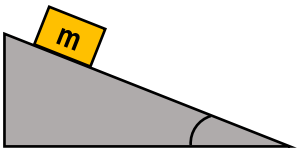
● For objects on rough inclines, there are 2 special angles called _____ angles:

- For both critical angles, $\boldsymbol{a}$ = ___.

1) $\boldsymbol{\theta_{crit,s}}$ → block "*STARTS sliding*": ____ = _____

$\boldsymbol{\theta_{crit,s}}$ = _____ ⇔ $\boldsymbol{\mu_s}$ = _____

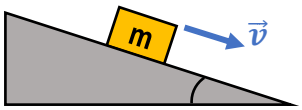
EXAMPLE: You place a 6kg block on an adjustable ramp, then tilt the angle of the ramp very slowly until the block suddenly **starts sliding.** If μ_s = 0.75, calculate this special angle.



2) $\boldsymbol{\theta_{crit,k}}$ → block "*slides at constant speed*": ____ = ____

$\boldsymbol{\theta_{crit,k}}$ = _____ ⇔ $\boldsymbol{\mu_k}$ = _____

EXAMPLE: Using the same ramp, once the block begins sliding you tilt the ramp so that the block slides down at **constant speed.** If μ_k = 0.31, calculate this special angle.



● For critical angles, **(1)** μ_s & $\theta_{crit,s}$ and **(2)** μ_k & $\theta_{crit,k}$ *only* depend on each other, not on any other variable (e.g. mass).

PROBLEM: A 3-kg block is at rest on an adjustable ramp. When the ramp is tilted to a 20° angle, the block slides with a constant velocity. What is the coefficient of kinetic friction between the ramp and the block?

A) μ_k=0.24
B) μ_k=0.36
C) μ_k=0.52
D) Not enough information given

$\boldsymbol{\theta_{crit,s}} = \tan^{-1}(\mu_s)$
$\boldsymbol{\mu_s} = \tan(\theta_{crit,s})$
$\boldsymbol{\theta_{crit,k}} = \tan^{-1}(\mu_k)$
$\boldsymbol{\mu_k} = \tan(\theta_{crit,k})$

PROBLEM: In the afternoon, a car is parked on a street that runs down a steep hill, at an angle of 35.0° relative to the horizontal. After a snowstorm hits the area, and the road becomes icy and just slippery enough for the car to slide downhill. What is the coefficient of static friction between the car tires and the icy road?

A) μs=0.47
B) μs=0.70
C) μs=1.54
D) Not enough information given

$\boldsymbol{\theta_{crit,s}} = \tan^{-1}(\mu_s)$
$\boldsymbol{\mu_s} = \tan(\theta_{crit,s})$
$\boldsymbol{\theta_{crit,k}} = \tan^{-1}(\mu_k)$
$\boldsymbol{\mu_k} = \tan(\theta_{crit,k})$