Phys 131 2025

Lecture 18

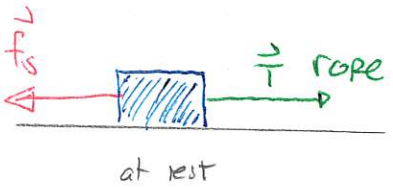
Free Tues: Discussion / quiz

Ex 189, 194, 195, 197, 199, 205, 208

Thurs

Static friction

Static friction is a force between two surfaces that arises when the surfaces do not move relative to each other. The static friction opposes the motion that would otherwise occur and has a maximum



at rest

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

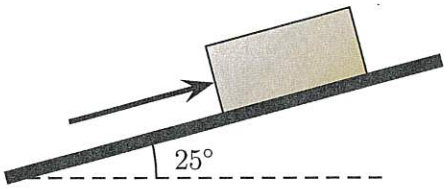
In general it adjusts to the situation and

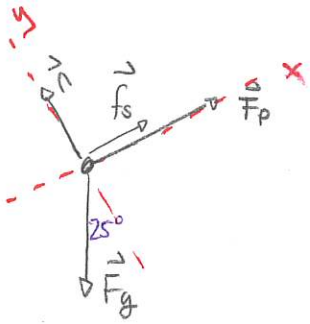
$$f_s \leq \mu_s n$$

Quiz 1 40% - 50%

206 Box held at rest on a rough ramp

A 30 kg block lies on a ramp at angle 25° from the horizontal. A person pushes parallel to the surface and uphill with a 80 N force. Determine the minumum coefficient of static friction so that the box stays at rest. *(131Sp2025)*



Answer: ① 

② $\Sigma F_{ix} = ma_x = 0$

$\Sigma F_{iy} = ma_y = 0$

Tilt axes

③ Components

$F_g = mg$

$F_{gx} = -mg\sin 25°$

$F_{gy} = -mg\cos 25°$

	x	y
F_g	$-mg\sin 25°$	$-mg\cos 25°$
n	0	n
F_p	F_p	0
f_s	f_s	0

④ $\Sigma F_{ix} = 0 \Rightarrow -mg\cos 25° + F_p + f_s = 0$

$\Rightarrow -30\text{kg} \times 9.8\text{m/s}^2 \sin 25° + 80\text{N} + f_s = 0 \Rightarrow f_s = 44\text{N}$

$\Sigma F_{iy} = 0 \Rightarrow -mg\cos 25° + n = 0$

$\Rightarrow n = mg\cos 25° \Rightarrow n = 267\text{N}$

⑤ Use static friction max $f_s \le \mu_s n$

$\Rightarrow 44\text{N} \le \mu_s 267\text{N}$

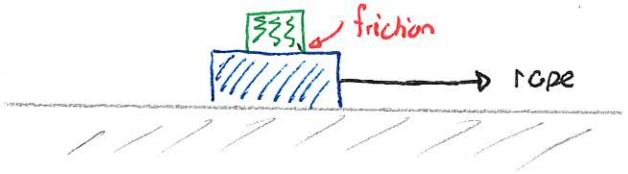
$\Rightarrow \mu_s \ge \frac{44\text{N}}{267\text{N}} \Rightarrow \mu_s \ge 0.17$

Interacting objects

Most interesting physics situations involve two or more objects that interact with each other while moving. The motion of each object is related in some way to the motion of the other.

DEMO: YouTube The Top 10 Coolest Funiculars ~ 5:15

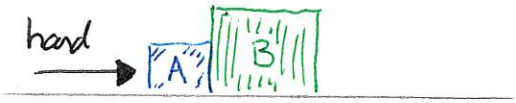
In some situations the two objects do not move together. We could consider two stacked blocks with friction between them. If the lower block is dragged by a rope then we would want to know:



* max tension without slipping
* if slipping occurs, what is friction?

We need rules for the force that one object exerts on the other and vice-versa.

Consider two blocks that can slide on a frictionless horizontal surface and that are in contact. They maintain contact while the hand pushes. Thus they move with the same acceleration



Warm Up !

The blocks accelerate to the right with acceleration a.

Considered as a single moving object

$\vec{F}_{net} = m\vec{a}_{total}$

gives

$a = \dfrac{F_{hand}}{m_A + m_B}$

→

Block B accelerates and Newton's 2nd Law for just B gives

$F_{A\,on\,B} = m_B a$

$= \dfrac{m_B}{m_A + m_B} F_{hand}$

↳ Block a accelerates and Newton's 2nd Law for block A

$\Rightarrow F_{net\,A} = m_A a$

$\Rightarrow F_{net\,A} = \dfrac{m_A}{m_A + m_B} F_{hand}$

The net force on A is less than F_{hand}

$\Rightarrow$ B must exert a force on A

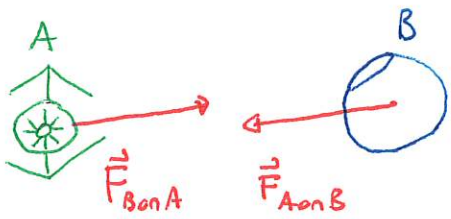
Newton's Third Law clarifies this.

Consider two objects A and B.

If object A exerts a force on object B then

1) object B exerts a force on A

2) the force vectors have equal magnitude and opposite directions $\Rightarrow \vec{F}_{B\text{ on }A} = -\vec{F}_{A\text{ on }B}$



Note: 1) the forces in Newton's third law are exerted by different objects and act on different objects

2) the forces are called an action-reaction pair.

Warm Up 2

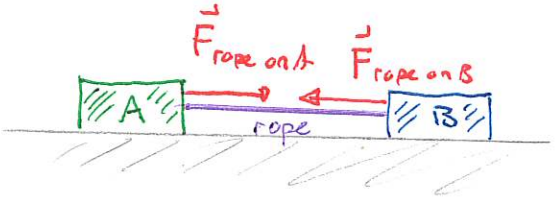
Quiz 2 40%

Objects connected by ropes

When two objects are connected by ropes. We would have to consider three objects but the following assumptions simplify the situation:

1) the rope does not stretch and is taut

2) the rope is massless



If the rope is massless then the net force on the rope is zero since $\vec{F}_{net} = M\vec{a} = 0$

Thus $F_{A\text{ on rope}} = F_{B\text{ on rope}}$. Then Newton's third Law gives

$F_{rope\text{ on }A} = F_{rope\text{ on }B}$. Thus the force exerted by either end of the rope is the same. This is the tension in the rope, So the tension is the same on either end