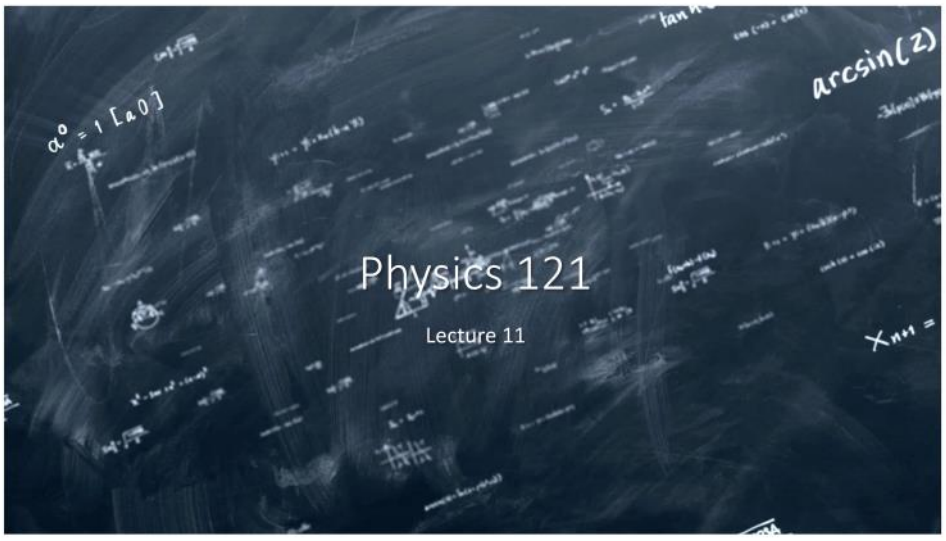
Lecture 11 - 2.14

Wednesday, February 15, 2023 8:58 AM



Envisioning BYU

D&C 88:67 And if your eye be single to my glory, your whole bodies shall be filled with light, and there shall be no darkness in you; and that body which is filled with light ***comprehendeth all things***.

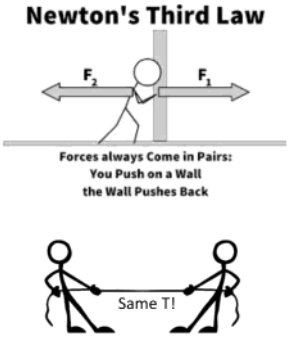
Create your own sunrise!
→Hel 3:35
→Mosiah 3:19

Review

Newton's first
A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless acted on by a net external force.

Newton's second
The acceleration of a system is directly proportional to and in the same direction as the net external force acting on the system and is inversely proportional to its mass.

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



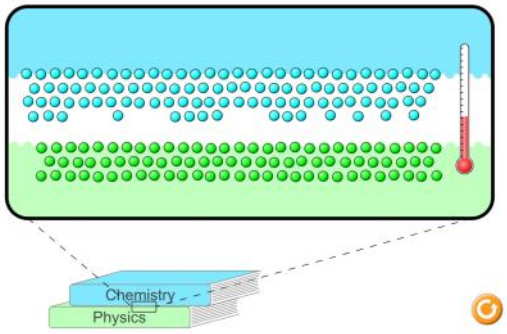
Discussion: What is going on here?

Bottom

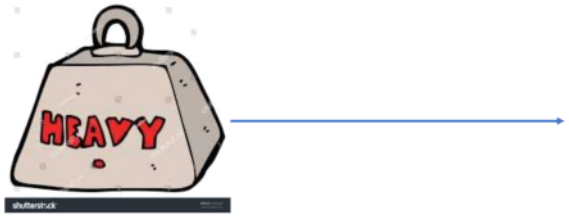
Top

Let's rub stuff!

https://phet.colorado.edu/sims/html/friction/latest/friction_en.html

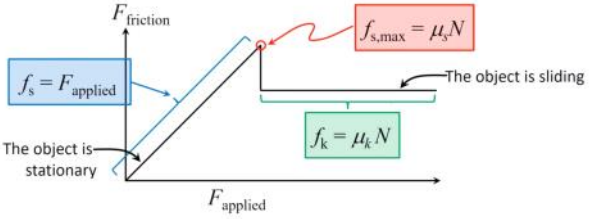


Two types of friction - experiment



Things you need to know about friction

- Friction opposes motion



static friction force

$f_s = F_{applied}$ ← Linear to F

$f_{s,max} = \mu_s \cdot N$

kinetic friction force

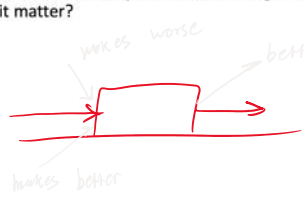
$f_k = \mu_k \cdot N$

- μ is coefficient of friction for the object/material
- N is normal force

iClicker: Push or pull?

You have to slide a box across a flat, horizontal floor. From the standpoint of minimizing the force of friction, is it better to push or pull the box, or does it matter?

A. Push
B. Pull
C. It doesn't matter
D. It depends



Friction

FRICTION

Friction is a force that opposes relative motion between systems in contact.

$f_s \leq \mu_s N$,

Static Friction

$f_k = \mu_k N$

Kinematic Friction

always max case

$f_s = \mu_s N$

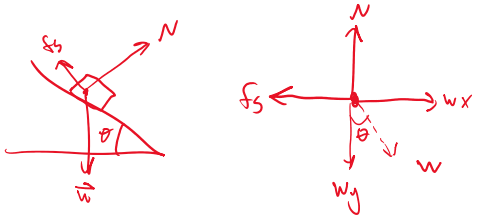
Example Values

System	Static Friction μ_S	Kinetic Friction μ_K
Rubber on dry concrete	1.0	0.7
Rubber on wet concrete	0.5-0.7	0.3-0.5
Wood on wood	0.5	0.3
Waxed wood on wet snow	0.14	0.1
Metal on wood	0.5	0.3
Steel on steel (dry)	0.6	0.3
Steel on steel (oiled)	0.05	0.03
Teflon on steel	0.04	0.04
Bone lubricated by synovial fluid	0.016	0.015

Gravity Experiment

Can we find the Coefficient of Friction if we know the angle?

Can we find the Coefficient of Friction if we know the angle?



$w_x = w \sin\theta$

$w_y = w \cos\theta$

$\sum F_x = 0$

$f_s = \mu_s \cdot N$

$N = -w_y$

$w \sin\theta - \mu_s \cdot w \cos\theta = 0$

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

The normal force?

Q3: In the previous problem, before the block starts to slide, how does the normal force change when the angle increases?

A. It gets bigger .

B. It stays the same

C. It gets smaller

Earthquake simulator

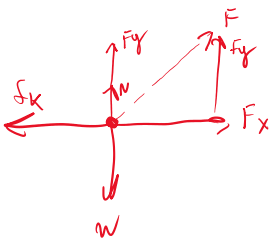
Earthquake simulator

- Elastic tension builds up in Earth's crust
  (driven by convection currents in the mantle and isostacy in the crust)
- The tectonic plates stay put because of friction
- When the tension becomes great enough, the plates shift
- This releases the tension for a while and the plates stop moving until the tension builds up again
- Using GPS detectors, we can accurately measure how the plates move

iClicker: Push or pull?

You have to slide a box across a flat, horizontal floor. You apply a force F at some angle with respect to the horizontal. What is the friction force? What force F is needed to sustain motion?

Talk to your neighbor for a minute: How do you start this problem?



$W = mg$

$N = W - F_y = mg - F\sin\theta$

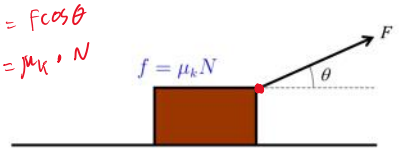
$F_y = F\sin\theta$

$F_x = F\cos\theta$

$f_k = \mu_k \cdot N$

$\sum F_x = m \cdot a_x$

$-m \cdot a_x + F\cos\theta = f_k$



Friction math is easy, but tedious.

- Provide pointers for this problem!

$f_x = F\sin\theta$

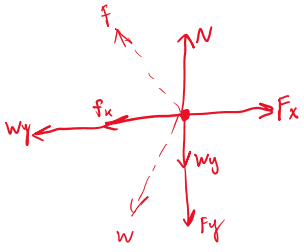
$F_y = F\cos\theta$

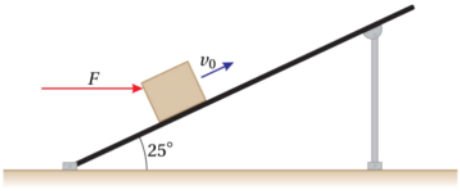
$W_x = W\sin\theta$

$W_y = W\cos\theta$

$N = F_y + W_y$

$f_k = \mu_k \cdot N$



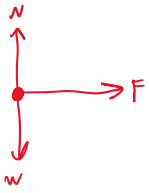


$\sum F_y = 0$ $\quad\quad$ $\sum F_x = m \cdot a_x$

https://www.youtube.com/watch?v=B-4NuNelk3Q#t=1m30s

Pulling an airplane

Ultrastrongman Eddie Hall pulls a 44,000 pound (20,000 kg) airplane 25 meters in 60 seconds. Neglecting friction, and assuming constant acceleration, what force is required to do this?



$\Sigma F = F = m \cdot a$

$F = 20{,}000\,kg \cdot \frac{50\,m}{3600\,s^2}$

$= 200 \cdot \frac{50}{36}$

$= \frac{10000}{36} N = 277.7\,N$

$x(0) = 0$

$x(t = 60s) = 25m$

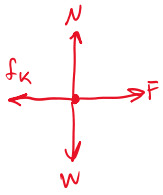
$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$

$x(60) = 25m = \frac{1}{2} a (60s)^2 = a = \frac{50m}{3600\,s^2}$

Pulling an airplane

Ultrastrongman Eddie Hall pulls a 44,000 pound (20,000 kg) airplane 25 meters in 60 seconds. If the coefficient of friction in the wheel bearings is 0.01, what force is required to do this?

$\mu_k = 0.01$



$f_k = \mu_k \cdot N$

$N = m \cdot g$

$\sum F_Y = m \cdot a$

$-f_k + F = m \cdot a$

$-\mu_k \cdot mg + F = m \cdot a$

$F = m \cdot a + \mu_k \cdot mg = 300N + 0.01 \cdot 20000 \cdot 9.8$

$300 + 200 \cdot 9.8$

$300 + 1960$

$2260N$

Exit Poll

- Please provide a letter grade for todays lecture:

A. A
B. B
C. C
D. D
E. Fail