PHYS 1443 – Section 003
Lecture #10

Wednesday, March 3, 2021

Dr. Jaehoon Yu

- CH4: Newton's Laws of Motion
  - Application of Newton's Laws
  - Force of Friction
  - Motion with friction
- CH5: Circular Motion and Gravitation
  - Kinematics of Uniform Circular Motion
  - Dynamics of Uniform Circular Motion

Announcements

- Mid-term comprehensive in class next Wednesday, March 10
  - Covers CH1.1 through what we learn on Monday, March 8 + Math refresher
  - BYOF: You may bring a one 8.5x11.5 sheet (front and back) of **handwritten** formulae and values of constants for the test
  - No derivations, word definitions, setups or solutions of any problems, figures, pictures, diagrams or arrows, etc!
  - Must email me the photos of front and back of the formula sheet, including the blank at jaehoonyu@uta.edu no later than **12:00pm the day of the test**
    - The subject of the email should be the same as your file name
    - File name must be FS-E2-LastName-FirstName-SP21.pdf
    - Once submitted, you cannot change, unless I ask you to delete part of the sheet!
- Reminder: Extra credit special COVID seminar at 4pm Saturday, March 20
  - Extra credit for participation and for asking the relevant questions
  - Dr. Linda Lee, a practicing physician from Wisconsin

Reminder: SP #3 – Statistical Analysis : COVID19

- Make comparisons of COVID-19 statistics between the U.S., South Korea, Italy and Texas from https://coronaboard.com on spreadsheet
  - Total 44 points: 1 point for each of the top 20 cells and 2 points for each of the 8 cells for vaccination
- Fill the US Historic event analysis table at the bottom 12 cells of the sheet (2 points per cell, 24 points total) and make a >3 sentence statement on COVID19 with respect to other events (6 points)
- What are the 3 fundamental quantitative requirements for opening up (2 points each, 6 points total)?
  - **Must be quantitative! (e.g. number of tests per capita per day, positivity rate, etc)**
- Assess the readiness of the three fundamental requirements U.S. (Do NOT just take politician's words!). Must provide the independent scientific entity's reference you took the information from. (2 point each, total 6 points)
- Evaluate **quantitatively** the success/failure of the US responses to COVID-19 in 2020 in 5 sentences and that in 2021 in 5 sentences. **Must provide quantitative reasons behind your conclusion!** (2 points each sentence, 20 points total)
- Assess **quantitatively** the effectiveness of wearing masks (4 points) and at least 4 reasons for it being effective (1 point each, 0.5 point extra after the first 4).
- **Possible maximum: 122 points total**
- **Due: 11pm, Friday, March 19**
  - Submit one pdf file SP3-YourLastName-YourFirstName.pdf, including the spreadsheet
  - Spreadsheet will be posted on canvas. Download ASAP.

PHYS1443-003, Spring 21, Special Project #3, Statistical Analysis - COVID19

Name:			Date & time of your COVID-19 Data:		
Items		**U.S.A**	**South Korea**	**Italy**	**Texas**
Total Population					
COVID-19 Confirmed cases	Total				
	Cases per 1M people				
COVID-19 Deaths	Total				
	Death per 1M people				
COVID-19 Testing	Total				
	Testing per 1M people				
	Poditivity Rate				
COVID-19 Vaccination to date	Total				
	Per 1M people				
		COVID-19	**US H1N1**	**US Vietnam War**	**US World War II**
US Historic Event Analysis	Time period (mm/dd/yy - MM/DD/YY)				
	Duration in Months				
	Total deaths				
	Death per month				

Reminder: SP#4 – Newton's 3rd Law

- The mass of the spacecraft is 11,000 kg and the mass of the astronaut is 92 kg. What is the velocity of the space craft and the astronaut 10 sec into the motion if they were in contact for 50cm during with the astronaut is applying the force of 36N?
- Maximum score: 20 points
- Please be sure to show details of your OWN work!
- Must be handwritten!
- Due 2:30pm, Monday, March 8
- Submit one pdf file SP4-YourLastName-YourFirstName.pdf on canvas assignment #4

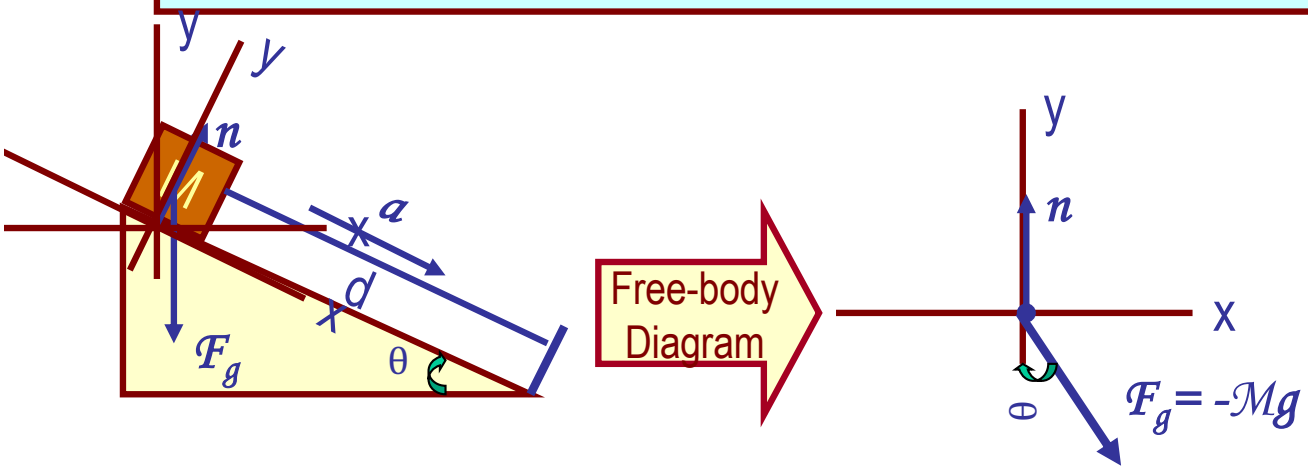
Steps for solving mechanics problems using Newton's Laws

1. Identify all the forces acting on the object of interest in the problem.
2. Establish a vector sum equation using all identified forces.
   - Note that the vector sum of all forces are the net force that provides the acceleration to the object's motion
3. Identify all components of the forces in each direction.
4. Establish the force equation for each component, whose right hand-side will be the mass of the object times the acceleration in the particular direction.
5. Solve each equation of component for the the quantities of interests.
6. If any further equation of motion is of interest, use combinations of kinematic equations to obtain the answers.

Example w/o Friction

A crate of mass M is placed on a frictionless inclined plane of angle θ.

a) Determine the acceleration of the crate after it is released.



$$\vec{F} = \vec{F}_g + \vec{n} = m\vec{a}$$

$$F_x = Ma_x = F_{gx} = Mg\sin\theta$$

$$a_x = g\sin\theta$$

$$F_y = Ma_y = n - F_{gy} = n - mg\cos\theta = 0$$

$$\Rightarrow n = mg\cos\theta$$

(b) Supposed the crate was released at the top of the incline, and the length of the incline is d. How long does it take for the crate to reach the bottom and what is its speed at the bottom?

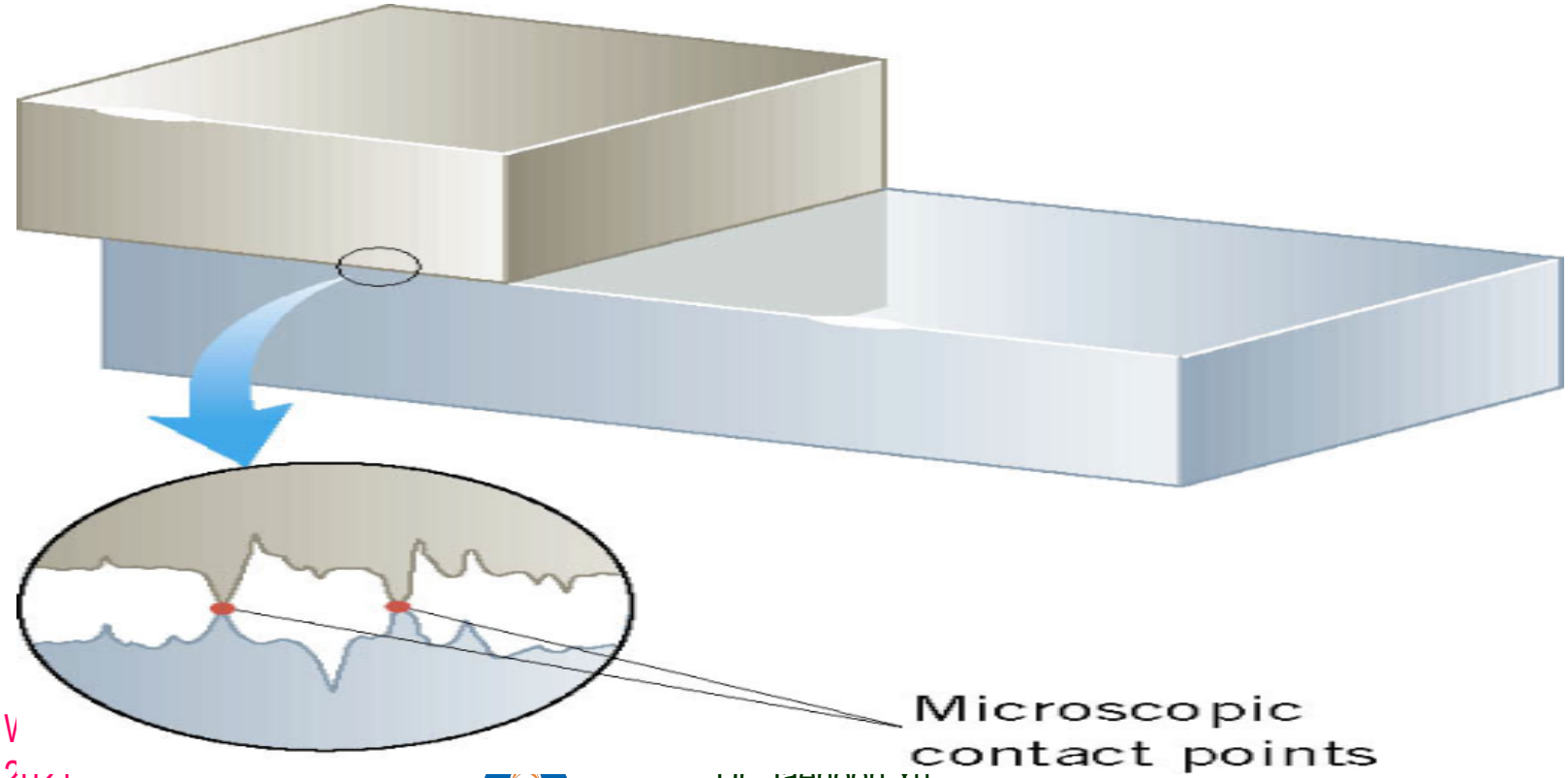
$$d = v_{ix}t + \frac{1}{2}a_x t^2 = \frac{1}{2}g\sin\theta\, t^2 \qquad \therefore t = \sqrt{\frac{2d}{g\sin\theta}}$$

$$v_{xf} = v_{ix} + a_x t = g\sin\theta\sqrt{\frac{2d}{g\sin\theta}} = \sqrt{2dg\sin\theta}$$

$$\therefore v_{xf} = \sqrt{2dg\sin\theta}$$

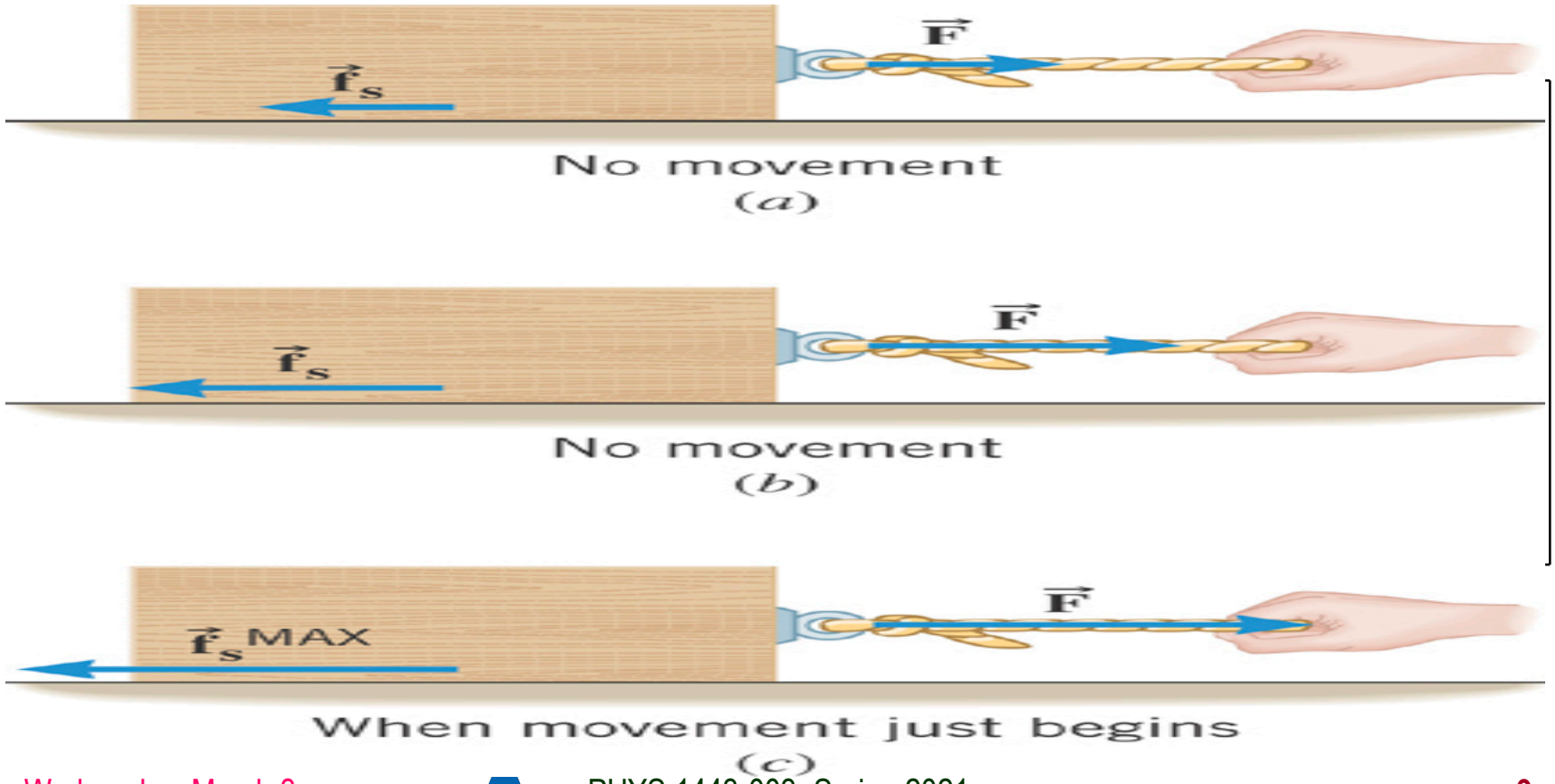
Friction Force

When an object is in contact with a surface, there is a force acting on that object. The component of this force, parallel to the surface is called the ***friction force***. *This resistive force is exerted on a moving object due to The viscosity or other types of frictional property of the medium in or surface on which the object moves.* *Always opposite to the movement!!*



Static Friction

When the two surfaces are not sliding against one another, the friction is called ***static friction***. *This resistive force acts on the object up to the time just before the object starts moving.*



Magnitude of the Static Friction

The magnitude of the static friction force can have any value from zero up to the maximum value.

$$f_s \leq f_s^{MAX}$$

$$f_s^{MAX} = \mu_s F_N$$

$0 < \mu_s < 1$ is called the **coefficient of static friction**.

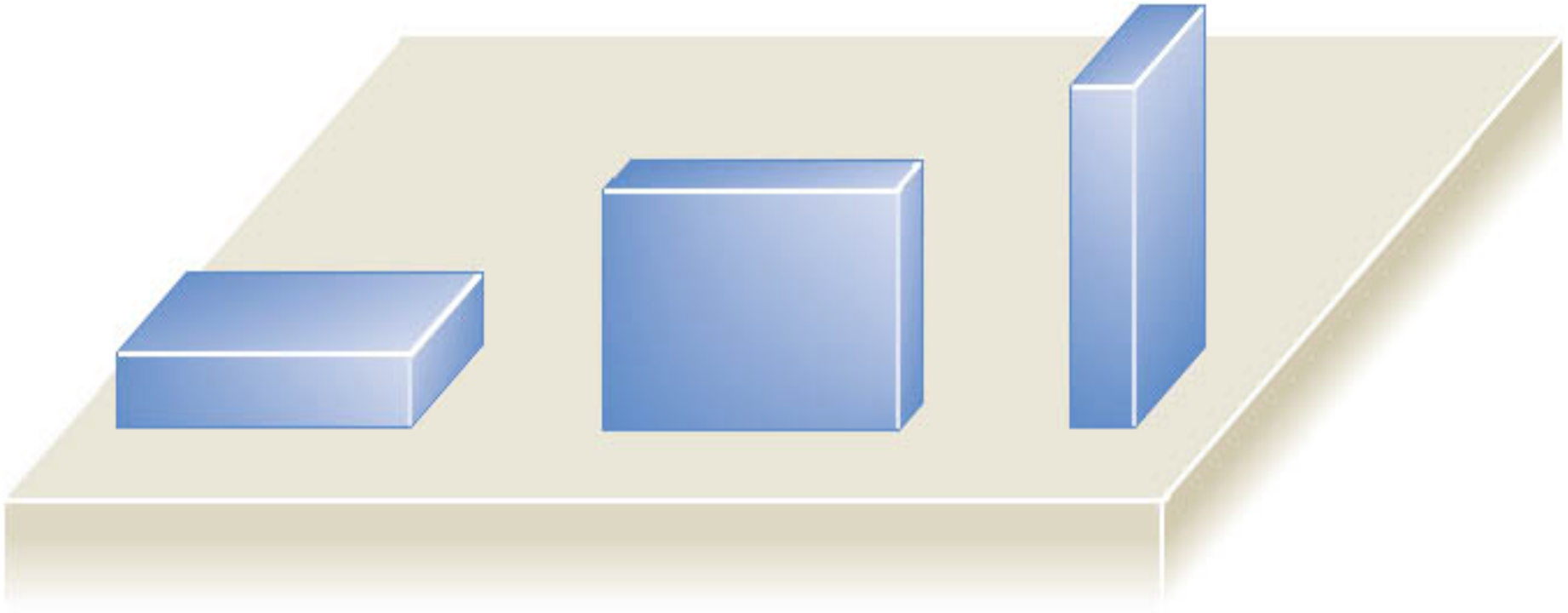
What is the unit? None

Once the object starts moving, there is **NO MORE** static friction!!

Kinetic friction applies during the move!!

Note that the magnitude of the static friction force **does not depend on the contact area of the surfaces**.

$$f_s^{MAX} = \mu_s F_N$$



Kinetic Friction

Static friction opposes the *impending* relative motion between two objects.

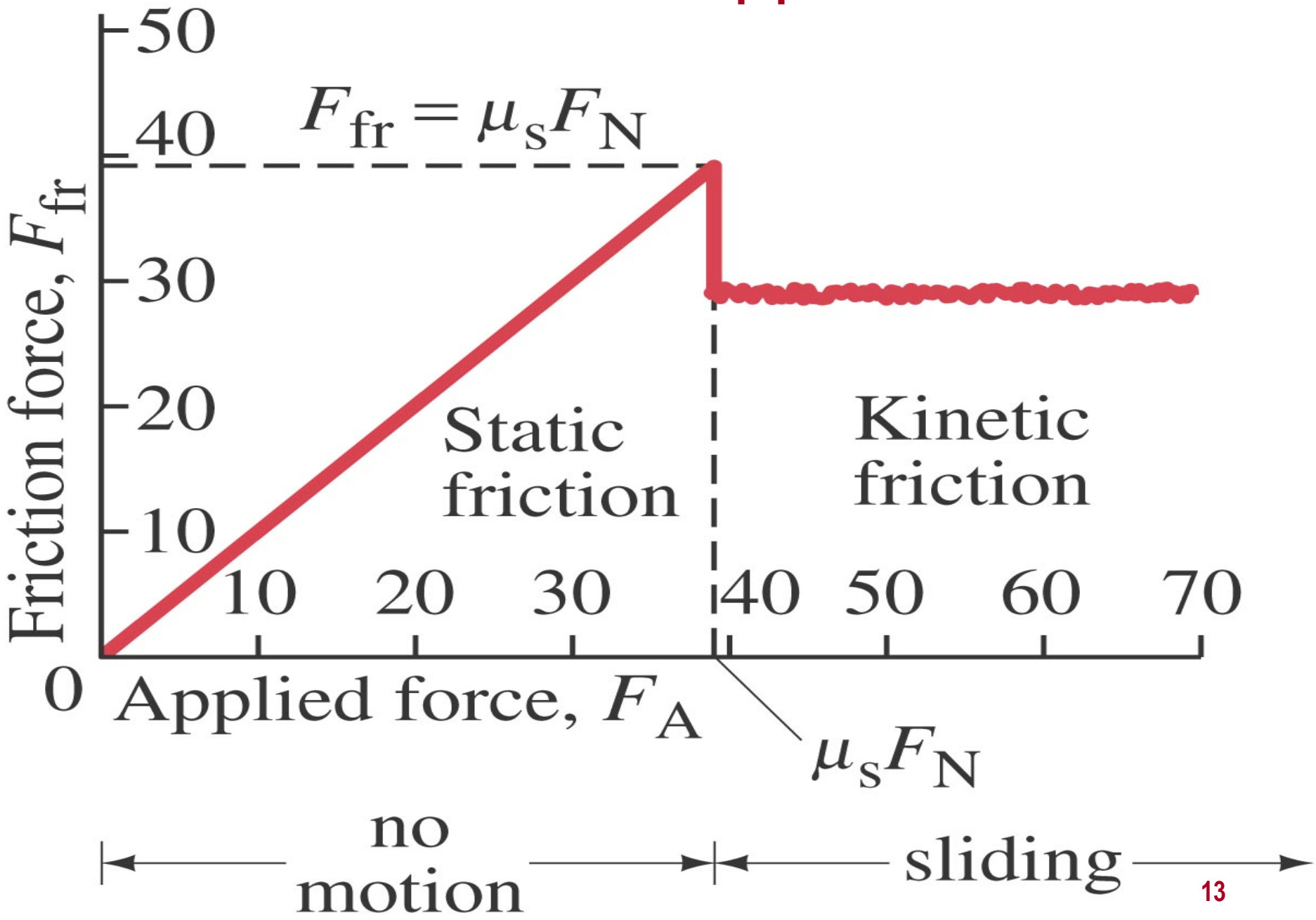
Kinetic friction opposes the relative sliding motions that is happening. *This resistive force acts on the objects only during its movement.* *Normally much smaller than the static friction!!*

$$f_k = \mu_k F_N$$

$0 < \mu_k < 1$ is called the **coefficient of kinetic friction**.

What is the direction of friction forces? **opposite to the movement**

Friction Force vs Applied Force



Coefficients of Friction

Coefficients of Friction†

Surfaces	Coefficient of Static Friction, μ_s	Coefficient of Kinetic Friction, μ_k
Wood on wood	0.4	0.2
Ice on ice	0.1	0.03
Metal on metal (lubricated)	0.15	0.07
Steel on steel (unlubricated)	0.7	0.6
Rubber on dry concrete	1.0	0.8
Rubber on wet concrete	0.7	0.5
Rubber on other solid surfaces	1–4	1
Teflon® on Teflon in air	0.04	0.04
Teflon on steel in air	0.04	0.04
Lubricated ball bearings	<0.01	<0.01
Synovial joints (in human limbs)	0.01	0.01

†Values are approximate and intended only as a guide.

What are these?

Forces of Friction Summary

Resistive force exerted on a moving object due to viscosity or other types frictional property of the medium in or surface on which the object moves.

These forces are either proportional to the speed or the normal force.

Force of static friction, f_s: *The resistive force exerted on the object until just before the beginning of its movement*

Empirical Formula $\left|\vec{f}_s\right| \le \mu_s \left|\vec{F}_N\right|$

What does this formula tell you?

Static friction force increases till it reaches the limit!!

Beyond the limit, the object moves, and there is **NO MORE** static friction but the kinetic friction takes it over.

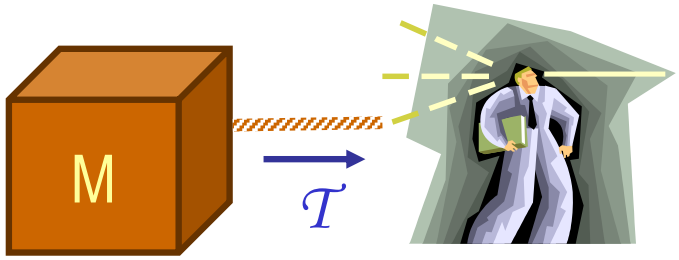
Force of kinetic friction, f_k $\left|\vec{f}_k\right| = \mu_k \left|\vec{F}_N\right|$

The resistive force exerted on the object during its movement

Which direction does kinetic friction apply? Opposite to the motion!

Look at this problem again…

Suppose you are pulling a box on a rough surfice, using a rope.



What are the forces being exerted on the box?

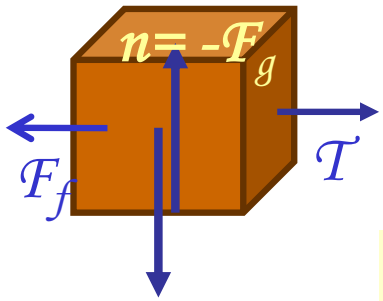
Gravitational force: F_g

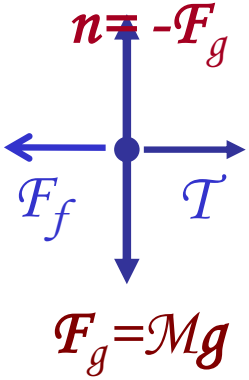
Normal force: n

Tension force: T

Friction force: F_f

Free-body diagram





Total force: $F=F_g+n+T+F_f$

$$\sum F_x = T - F_f = Ma_x \qquad a_x = \frac{T - F_f}{M}$$

$$\sum F_y = -F_g + n = Ma_y = 0 \qquad a_y = 0 \qquad n = F_g$$

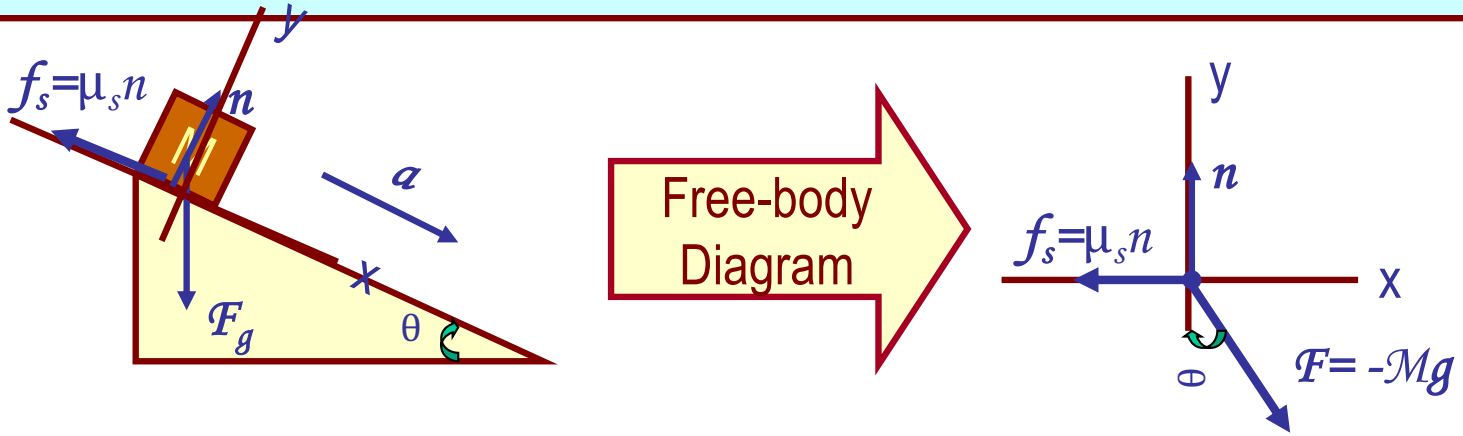
If T is a constant force, a_x is constant

$$v_{xf} = v_{xi} + a_x t = v_{xi} + \left(\frac{T - F_f}{M}\right)t$$

$$\Delta x = x_f - x_i = v_{xi}t + \frac{1}{2}\left(\frac{T - F_f}{M}\right)t^2$$

Example w/ Friction

Suppose a block is placed on a rough surface inclined relative to the horizontal. The inclination angle is increased till the block starts to move. Show that by measuring this critical angle, θ_c, one can determine coefficient of static friction, μ_s.



Net force $\vec{F} = M\vec{a} = \vec{F}_g + \vec{n} + \vec{f}_s$

x comp. $F_x = F_{gx} - f_s = Mg\sin\theta - f_s = 0 \quad f_s = \mu_s n = Mg\sin\theta_c$

y comp. $F_y = Ma_y = n - F_{gy} = n - Mg\cos\theta_c = 0 \quad n = F_{gy} = Mg\cos\theta_c$

$$\mu_s = \frac{Mg\sin\theta_c}{n} = \frac{Mg\sin\theta_c}{Mg\cos\theta_c} = \tan\theta_c$$

Motion in Resistive Force

A medium can exert resistive forces on an object moving through it due to viscosity or other types frictional properties of the medium.

Some examples? Air resistance, viscous force of liquid, etc

These forces are exerted on moving objects in the opposite direction to the movement.

These forces are proportional to such factors as speed. They almost always increase with increasing speed.

Two different cases of proportionality:

1. Forces linearly proportional to speed:
   Slowly moving or very small objects
2. Forces proportional to square of speed:
   Large objects w/ reasonable speed