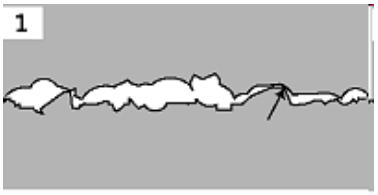
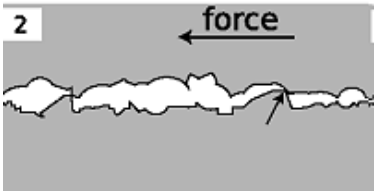




Microscopic bumps and holes crash into each other, causing a **frictional** force.

Kinetic Friction creates internal energy (thermal).

PHY131 F Fall 2020
Class 10

Today:

- Friction: kinetic and static
- Tips for the Ch.4 Pre-Quiz

1

Ch.4 Pre-Quiz

Due Oct 5 at 8:45pm **Points** 16 **Questions** 2
Available after Sep 30 at 6pm **Time Limit** None

Quiz Instructions

Fill out your answers to both questions on the Answer Template Sheet.pdf . You can choose between two ways to do this:

- Paper-Method: Print the Answer Template Sheet, write out your solution, take a photo in good light, and upload the image to the question.
- Tablet-Method: Use a tablet or writing software of some kind to write on the PDF itself. Upload the modified PDF to the question.

You may only upload one file per question - it should be a full image of your written solution on one side of paper, as per the Answer Template Sheet.

2

Ch.4 Pre-Quiz

To be awarded maximum credit, you must show each step in the problem-solving strategy clearly, completely and correctly. You may earn up to 2 points per step (for a total of 8 points per question). The four problem-solving steps are:

1. Sketch and translate
   - Sketch the process, label the physical quantities and identify unknowns.
   - If the problem involves Newton's laws identify an appropriate system.

3

Ch.4 Pre-Quiz

2. Simplify and diagram
   - Identify what simplifying assumptions are necessary to solve the problem.
   - When using kinematics, construct a motion diagram or a position-time graph.
   - When using Newton's laws, construct a force diagram for the system.
   - Force diagrams **must** include labeled forces with the "1 on 2" subscripts, where 2 is always the object under consideration, and 1 is always the external object providing the force. For example, the force of gravity on an object "o" could be labeled $F_{g\,E\,on\,o}$, where "E" stands for Earth.

4

Ch.4 Pre-Quiz

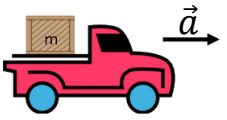
3. Represent mathematically
   - Using your representation in Step 2, clearly apply the relevant physics model to relate known physical quantities to the unknown quantity for which you wish to solve.
   - You may drop the "1 on 2" subscripts for this step, if you wish.
   - Do not plug in numbers immediately.
4. Solve and evaluate
   - Rearrange the equation and solve for the unknown quantity.
   - Substitute known values for variables and include units.
   - Clearly indicate your final answer.
   - You **must** evaluate your answer by comparing its magnitude with something else, or stating whether the sign and units are reasonable.

5

"Does friction **always** slow things down?"

ANSWER: No!

Kinetic friction on an object from a stationary surface does always slow down the object. But there are other kinds of friction. And sometimes the surface is moving!



"Can friction ever speed things up?"

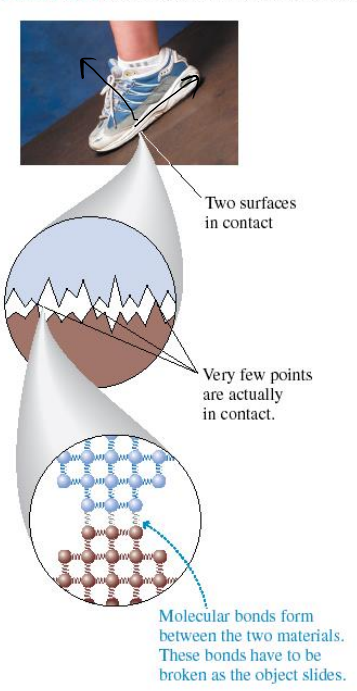
ANSWER: Yes!

Static friction of the floor on the bottom of your shoes is what allows you to walk! Walking certainly involves speeding up, and this would not be possible if the floor were frictionless or covered in marbles!

6

Why does friction exist?

Because at the microscopic level, ***nothing is smooth!***

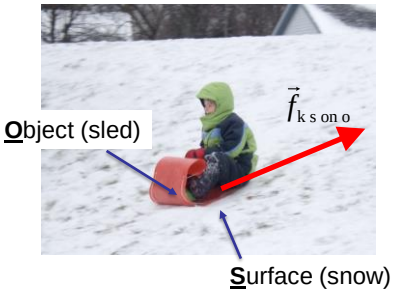


7

"Kinetic Friction"

$\vec{f}_{\text{k s on o}}$

- Sliding friction of a **s**urface on an on a moving **o**bject.
- When two flat surfaces are in contact and sliding relative to one another, heat is created, so it slows down the motion (kinetic energy is being converted to thermal energy).
- Many experiments have shown the following approximate relation usually holds for the magnitude of f_{k}:



$$f_{\text{k s on o}} = \mu_{\text{k}} N_{\text{s on o}}$$

where $N_{\text{s on o}}$ is the magnitude of the normal force of the surface on the object.

The direction of $\vec{f}_{\text{k}}$ is opposite the direction of motion of the **o**bject, relative to the **s**urface.

8

Poll Question

A wooden **b**lock weighs 100 N, and is sliding to the right on a smooth horizontal concrete **s**urface at a speed of 5 m/s. The coefficient of kinetic friction between wood and concrete is 0.1.

A 5 N horizontal force is applied to the block, pushing toward the right. What is the force of kinetic friction of the **s**urface on the **b**lock?

A. 100 N, to the left
B. 10 N, to the left
C. 5 N, to the left
D. 10 N, to the right
E. 5 N, to the right

9

Example

A slippery box of mass 5.0 kg is pulled at a constant velocity by a rope which makes an angle of 20.0° above the horizontal.

The coefficient of kinetic friction between the box and the surface is 0.030.

What is the tension in the rope?

Answer Template Sheet

1. SKETCH & TRANSLATE

2. SIMPLIFY & DIAGRAM

10

Example

A slippery box of mass 5.0 kg is pulled at a constant velocity by a rope which makes an angle of 20.0° above the horizontal.

The coefficient of kinetic friction between the box and the surface is 0.030.

What is the tension in the rope?

2. SIMPLIFY & DIAGRAM

11

Example

A slippery box of mass 5.0 kg is pulled at a constant velocity by a rope which makes an angle of 20.0° above the horizontal.

The coefficient of kinetic friction between the box and the surface is 0.030.

What is the tension in the rope?

12

Example

A slippery box of mass 5.0 kg is pulled at a constant velocity by a rope which makes an angle of 20.0° above the horizontal.

The coefficient of kinetic friction between the box and the surface is 0.030.

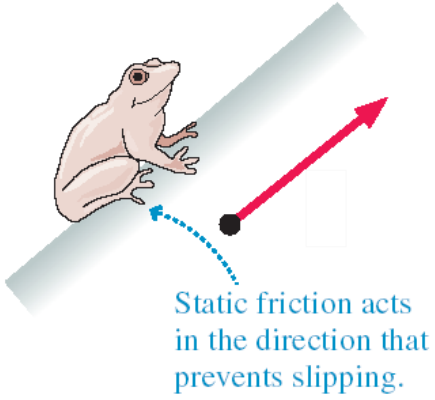
What is the tension in the rope?

4. SOLVE & EVALUATE

13

"Static Friction" $\vec{f}_{\text{s s on o}}$

- When an **o**bject is in contact with a **s**urface, but is not moving relative to that surface, it tends to resist slipping. The object and surface have sort of "locked" together. This creates a force of the surface on the object, perpendicular to the normal force, called static friction.



There is no general equation for $f_{\text{s s on o}}$.

The direction of $f_{\text{s s on o}}$ is whatever is required to prevent the object from slipping, relative to the surface.

ion.

14

Multiple Forces on a Single Object

- A car is parked on flat, horizontal pavement.
- Which of the following forces should be added to the force diagram of the car?

A. Gravity of Earth on Car, $\vec{F}_{g\ \mathrm{E\ on\ c}}$

B. Normal force of surface on car, $\vec{N}_{\mathrm{s\ on\ c}}$

C. Static friction of surface on car, $\vec{f}_{s\ \mathrm{s\ on\ c}}$

D. All of the above

E. A and B, but not C

15

Maximum Static Friction

There's a limit to how big $f_{\mathrm{s\ s\ on\ o}}$ can get. If you push hard enough, the object slips and starts to move. In other words, the static friction force has a *maximum* possible size $f_{\mathrm{s\ max}}$.

- The two surfaces don't slip against each other as long as $f_{\mathrm{s\ s\ on\ o}} \leq f_{\mathrm{s\ max}}$.
- A static friction force $f_{\mathrm{s\ on\ o}} > f_{\mathrm{s\ max}}$ is not physically possible. Many experiments have shown the following approximate relation usually holds:

$$f_{s\,max} = \mu_s N_{\mathrm{s\ on\ o}}$$

where $N_{\mathrm{s\ on\ o}}$ is the magnitude of the normal force of the surface on the object, and the proportionality constant μ_{s} is called the "coefficient of static friction".

16

Poll Question

A wooden **b**lock has a mass of 10.2 kg, so the force of gravity of the Earth on the block is 100 N. The block is sitting stationary on a smooth horizontal concrete **s**urface. The coefficient of static friction between wood and concrete is 0.2.

A 5 N horizontal force is applied to the block, pushing toward the right, but the block does not move. What is the force of static friction of the surface on the block?

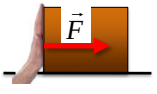
A. 100 N, to the left
B. 20 N, to the left
C. 5 N, to the left
D. 20 N, to the right
E. 5 N, to the right

17

Poll Question

A wooden **b**lock has a mass of 10.2 kg, so the force of gravity of the Earth on the block is 100 N. The block is sitting stationary on a smooth horizontal concrete **s**urface. The coefficient of static friction between wood and concrete is 0.2.

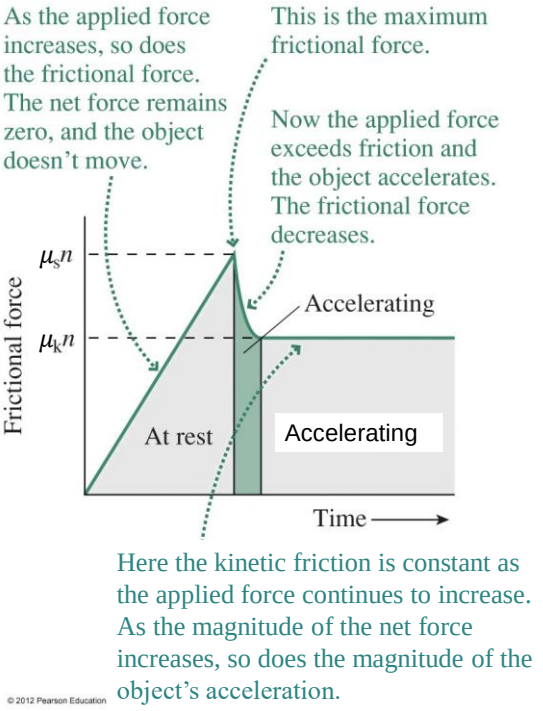
A horizontal force is applied to the block, pushing toward the right, but the block does not move. What is the magnitude of the maximum horizontal force you can exert on the block and have the block remain stationary?



A. 200 N
B. 100 N
C. 20 N
D. 10 N
E. 5 N

18

What happens if you steadily increase the applied force on an object which is resting on a surface?



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Typical Coefficients of Friction

Materials	Static μ_s	Kinetic μ_k
Rubber on concrete	1.00	0.80
Steel on steel (dry)	0.80	0.60
Steel on steel (lubricated)	0.10	0.05
Wood on wood	0.50	0.20
Wood on snow	0.12	0.06
Ice on ice	0.10	0.03

20

Before Class 11 on Monday

- Please read:
- 4.4 Solving Dynamics Problems in 2D
- 4.5 Projectile Motion