

Friction

I. Friction and Sliding Friction

A. Introduction

The study of friction is an important and complicated field of engineering and physics. There is no comprehensive theory for friction at the microscopic level. Instead, we have several different macroscopic equations and approximations depending on the type of friction. Tire companies spend considerable amount of money researching new designs to improve friction between the tires and the road while the automotive industry attempts to develop new fluids and manufacturing processes to reduce frictional wear. One interesting frictional process involves your knees. In order for you to stand, it is necessary that the friction between bones of the knee be very large otherwise you would wobble like a newborn colt. However, you require a much smaller frictional force between the knee joints in order to walk. The knee changes its frictional force by secreting and absorbing a liquid (you have a self-oilier!). Maybe now you will appreciate why knee injuries are so serious for athletes.

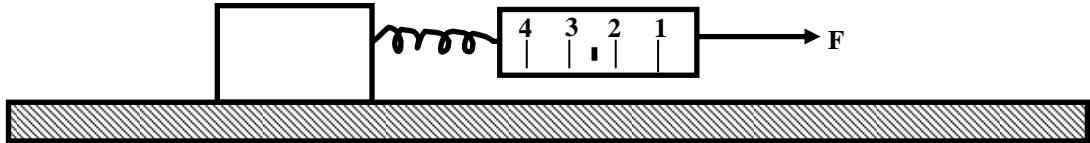
Two Common Misconceptions About Friction

- 1) Friction is a bad thing!
- 2) Friction always causes an object to slow down!

It is friction that allows your car to speed up and to make turns! Without friction, you couldn't stay in your seat when you wiggle or even leave the classroom when class was dismissed. Without friction, your car wouldn't come to a stop when you hit the brakes and you couldn't jack up your car to change a flat.

II. Static Friction

Leonard de Vinci developed the theory of sliding and static friction that is still used today. Consider a stationary block resting on a table. If we begin pulling on the block using a spring balance, the block will remain stationary until we reach some maximum force upon which time the block will begin to accelerate.



Free Body Diagram of the Block

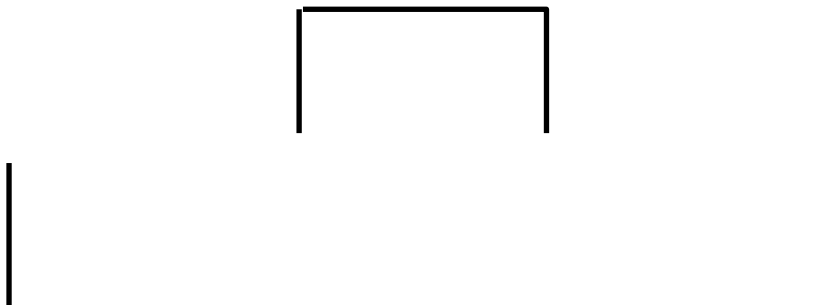
Newton II Equations for Stationary Block

Thus, when we plot a graph of the friction force f versus the applied force F we obtain the following graph:



Microscopic Picture

If we look at the block and table surfaces under a microscope, we would see millions of small sharp points. Sharp points on the table interact with sharp points on the block by applying normal forces that are perpendicular to each surface of contact. When the block is stationary, the sharp points on the block can reside in valley on the surface of the table and vice versa. When the force becomes too great the surface begin to move with respect to each other.



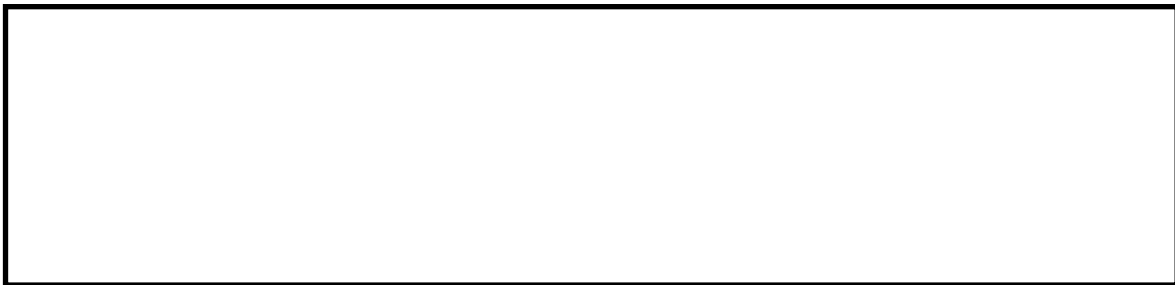
A. There is _____

for the **MAGNITUDE** of the STATIC FRICTION FORCE! Its value is whatever value is required to prevent _____ and **must be found** by **applying** _____ .

B. The **direction** of the STATIC FRICTION FORCE is **such that it** _____ motion.

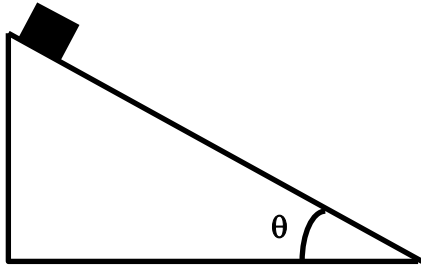
C. Special Case - Maximum Static Friction Force

The magnitude of the maximum static friction force is _____ to the magnitude of the normal force acting at the surface. The _____ depends on the physical properties of the two objects (material, smooth/rough, etc.) and is called the _____ of _____ .



The magnitude of the static friction force is always greater or equal to the magnitude of the sliding friction force.

Example: A block is at rest on an inclined plane as shown below. The angle of inclination is slowly increased. Assuming that the block just starts to slide when the angle of inclination reaches 40 degrees, what is the coefficient of static friction between the block and the plane?



Solution:

III. Sliding (Kinetic) Friction

A. Once an object begins sliding the frictional force becomes constant with a magnitude that is _____ to the _____.



B. The magnitude of the sliding friction force _____ of the relative _____ of the two surfaces!

C. The _____ of _____ _____ contains ALL information about the nature of the two surfaces (rough, etc.)

D. The direction of the sliding friction force is in the direction that _____.

Example: A block of mass 10.0 kg is initially at rest on an inclined plane with a 40.0 degree angle of inclination. Find the speed of the block after it has slide 5.00 m down the incline assuming that the coefficient of kinetic friction between the block and plane is 0.15.