Name: ____________________

Period: ____________________

Surface Friction

3.5

Friction (F_f) - Friction opposes motion. If you are moving left, friction tries to stop you by pulling right and vice versa. We will be studying only the two types of surface friction.

Increasing Surface Friction

If you wanted to increase the friction on an object you could either put the object on a rougher surface or push down on the object, grinding it into the surface.

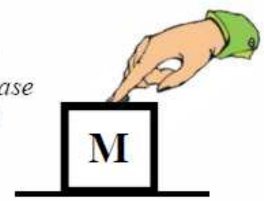
μ (pronouced "me-oo") is the coefficient of friction. Rougher surfaces have higher μ's.

The greater F_N is, the more the object is being ground into the surface, causing more friction.

Ice has a very low coefficient of static friction of 0.1, so you slip easily.

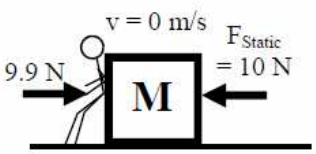
Rubber on concrete has a high coefficient of friction of 1.0, so tires grip well.

By pushing down you increase F_N and increase pressure of the object against the surface.

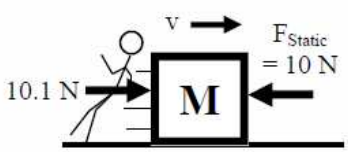


Static Friction (F_S)

Static friction is gripping friction. F_s tries to keep an object sticking to a surface. You must apply a force just greater than F_s to start the object sliding.



Since 9.9 N < 10 N, M won't slide.



Since 10.1 N > 10 N, M breaks free and starts to slide.

Use F_s to decide if the object slides.

If $F > F_s$ it starts to slide.
If $F < F_s$ it doesn't slide.

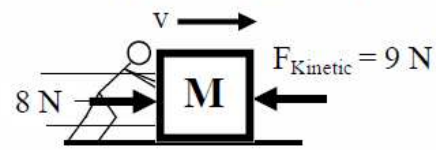
Remember: F_s never causes an object to start sliding on its own.

Static Friction (in N)	*Normal Force (in N)*
$$\mathbf{F_s \le \mu_s F_N}$$	
Coefficient of static friction (no units)	

CAUTION!
An object can't be slipping and gripping at the same time. Never add F_S and F_K.

Kinetic Friction (F_K)

Kinetic friction is slipping friction. F_K tries to stop an object from slipping, to make it stop. Kinetic friction is usually less than static friction.



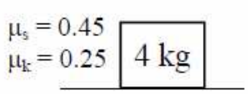
8 N < 9 N, so M will slow down and eventually stop.

Use F_k to calculate acceleration, since an object must be moving to be accelerating.

If $F > F_k$ it keeps sliding and accelerates.
If $F < F_k$ it will slow down and stop.
If $F = F_k$ it will stay moving at constant speed.

Kinetic Friction (in N)	*Normal Force (in N)*
$$\mathbf{F_k = \mu_k F_N}$$	
Coefficient of kinetic friction (no units)	

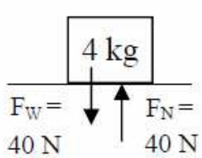
Example: Calculate static and kinetic friction for a 4 kg mass sitting on a table where $\mu_s = 0.45$ and $\mu_k = 0.25$.



Solution:

Step 1) Calculate Normal Force
(see "Normal Force" notes)

Since $a_y = 0$ m/s^2 and there are no other vertical forces, the normal force equals the weight of the object.



$F_N = F_W = 4(10) = 40$ N

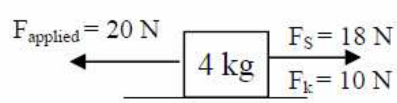
Step 2) Calculate Static and Kinetic Friction

$F_s = \mu_s F_N$
$F_s = 0.45(40)$
$F_s = 18$ N

*It takes 18 N **to start** M sliding.*

$F_k = \mu_k F_N$
$F_k = 0.25(40)$
$F_k = 10$ N

*It takes 10 N **to keep** M sliding.*



$\Sigma F = ma$
$-20 + 10 = 4a$

$-10 = 4a$
$a = -2.5$ m/s^2

Use F_k because it is slipping when it accelerates.

1. Static (Fs) or Kinetic (Fk) Friction?

_____ Tries to stop an object when it's moving.

_____ How much force to keep an object sliding.

_____ Slows down a sliding object.

_____ How much it takes to start an object sliding.

_____ Car tires when they "spin out".

_____ Requires F_N to calculate.

_____ Calculate with μ_k.

_____ On a playground slide.

_____ Sliding friction.

_____ Car tires normally.

_____ Is greater.

_____ Gripping friction

_____ Calculate with μ_s.

2. More or less friction?

A. _____ On a rougher surface.

B. _____ If F_N increases.

C. _____ If the surface is smoother.

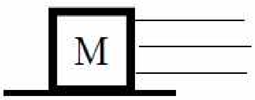
D. _____ If μ is less.

E. _____ If the object has more mass.

F. _____ If you push down on the object.

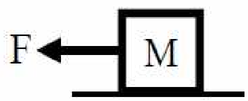
G. _____ If you pull up on the object.

H. _____ If μ increases.



3. An object is moving to the left. Which way does friction act?

4. A force is pulling on an object to the left. Draw an arrow showing the direction of static friction.

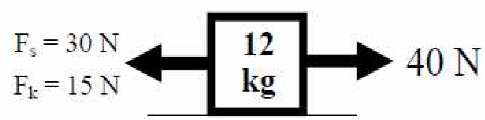


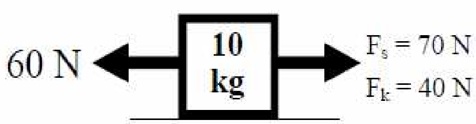
5. If $F_N = 50$ N and $\mu_s = .26$, find the force of static friction.

6. If $F_N = 25$ N and $\mu_k = .13$, calculate kinetic friction.

7. A. How much force is necessary to start the 12 kg object moving?
   B. How much force is necessary to keep it moving?
   C. If it starts at rest, will it start sliding?

   D. Calculate the acceleration of the object.

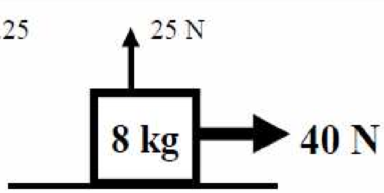




8. A. Does the object start sliding?
   B. If not, how much extra force is necessary?

   C. If it is moving calculate the acceleration of the object?

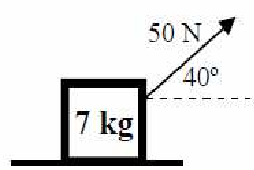
$\mu_s = .4$ $\mu_k = .25$



9. A. Calculate the normal force on the object.
   B. Calculate both static and kinetic friction.

   C. Does the object start moving?
   D. Calculate the acceleration if it is moving.

$\mu_s = .6$ $\mu_k = .3$



10. A. Does the 50 N increase or decrease F_N?
    B. Resolve the 50 N force into its x and y-components.

    C. Calculate F_N.

    D. Using F_N, calculate F_s and F_k.

    E. Will the object slide?
    F. Calculate the acceleration of the object if it does slide.