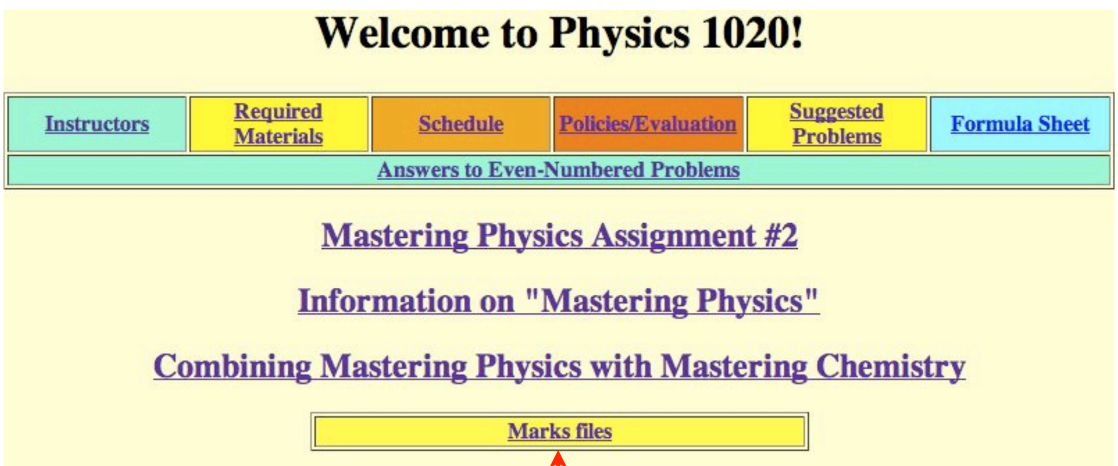
Mastering Physics Assignment 2

Is available on Mastering Physics website

Seven practice problems + six for credit on material from chapter 3

Due Wednesday, October 10 at 11 pm

On Campus Machines
Use Firefox if problems with Internet Explorer!



Marks for first Mastering Physics assignment (plus labs, tests when available)

http://www.physics.umanitoba.ca/~birchall/PHYS1020/

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

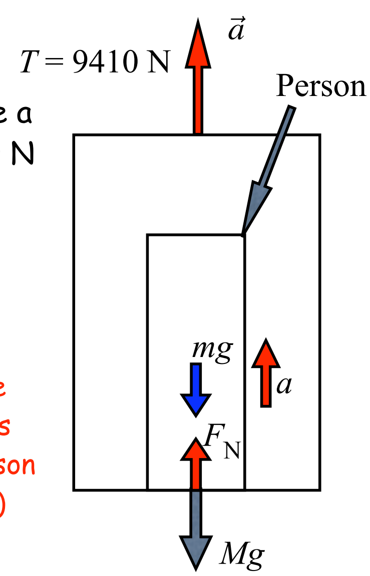
5	M	Oct 1	11			Tutorial and Test 1 (chapters 1, 2, 3)
	W	3	12	Chapter 5	Uniform circular motion	
	F	5	13			
6	M	8	Thanksgiving Day			Experiment 2: Measurement of *g* by free fall
	W	10	14	Chapter 5	Uniform circular motion	
	F	12	15	Chapter 6	Work and energy	
7	M	15	16			Tutorial and Test 2 (chapters 4, 5)
	W	17	17			
	F	19	18	Chapter 7	Impulse and momentum	
8	M	22	19			No lab or tutorial
	Tue	23	MID-TERM TEST, Ch 1-5, Tuesday, October 23, 7-9 pm			
	W	24	20	Chapter 7	Impulse and momentum	
	F	26	21	Chapter 8,	Rotational kinematics	

Week of October 1
Tutorial and test 1, ch. 1, 2, 3

Week of October 8
Experiment 2: Measurement of *g* by free fall

Apparent Weight

4.94/36: The person in the elevator has a mass m = 60 kg. The elevator and scale have a combined mass M = 815 kg. A force of 9410 N accelerates the elevator upwards. What is the apparent weight of the person?



The net upward force **on the person** is:

$$F_{net} = F_N - mg = ma$$

(this force accelerates just the person of mass m)

The apparent weight is F_N:

$$F_N = m(g+a)$$

So, what is the acceleration, a?

$F_N = m(g+a)$

Forces on elevator + contents

Person: m = 60 kg
Elevator + scale: M = 815 kg
Upward force on elevator: T = 9410 N

Net upward force on elevator:

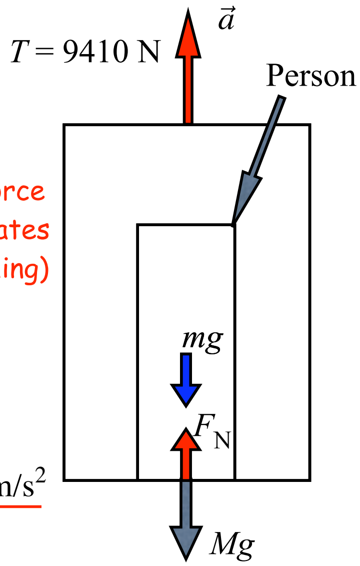
(this force accelerates everything)

$$F_{net} = T - (M+m)g = (M+m)a$$

$$\text{So, } a = \frac{T-(M+m)g}{M+m}$$

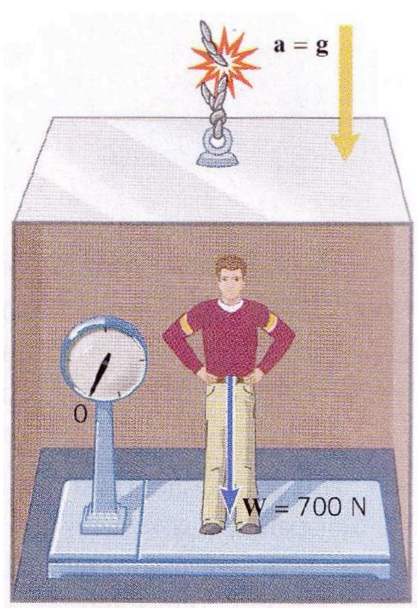
$$a = \frac{9410 - (815+60)\times 9.8}{815+60} = 0.954 \text{ m/s}^2$$

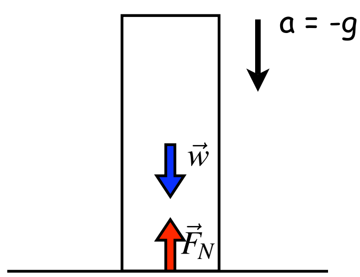
$$F_N = m(g+a) = 60 \times (9.8 + 0.954) = 645 \text{ N}$$



Scale reading = (645 N)/g = 66 kg

Apparent Weight - Free Fall: a = -g

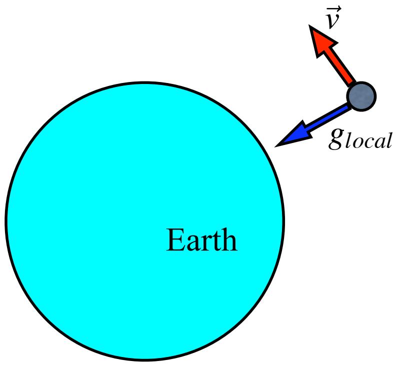




Apparent weight: $F_N = m(g + a)$

As a = -g, $F_N = 0$ “weightless”

Free Fall – Astronauts in Orbit

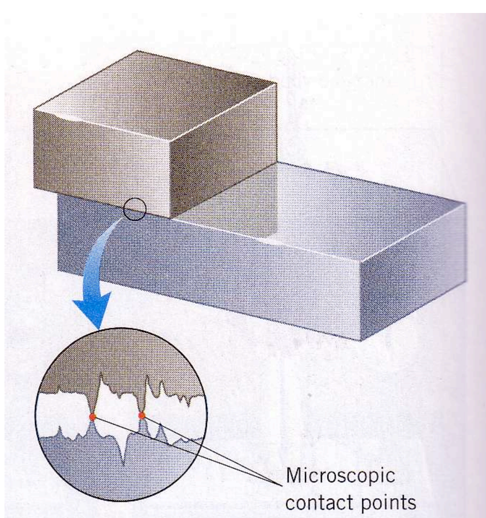


$$g_{local} = g\left(\frac{R_{earth}}{R_{orbit}}\right)^2$$

The spacecraft is accelerated toward the centre of the earth at a rate g_{local} (centripetal acceleration, chapter 5), which is the acceleration due to gravity at the radius of the orbit.

They are in free fall and "weightless". Bathroom scale reads zero.

Static and Kinetic Friction



Friction - due to uneveness of surfaces, even when polished.

Friction force increases the more the surfaces are pressed together.

Static friction - surfaces not sliding.

Kinetic friction - surfaces are sliding.

Surfaces smooth at the molecular level -

attractive inter-molecular forces bind surfaces together ("cold weld")

Static Friction

Static friction occurs when there is no sliding or skidding:

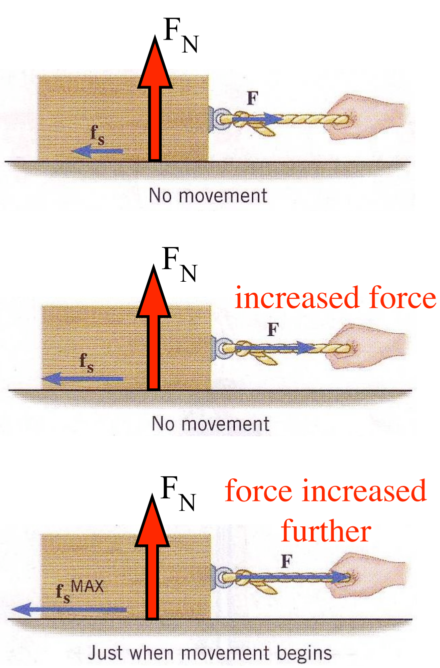
- object at rest
- car moving without skidding or spinning wheels – where the tire meets the road, the tire is momentarily at rest, so the friction is "static"

Kinetic Friction

There is sliding or skidding.

- usually less than the static friction force – hard to get an object sliding, and easier to keep it sliding.

Static Friction



The static friction force f_s opposes applied forces and increases as the applied force F is increased.

f_s rises only to a maximum value:

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

and then the block slides.

$\mu_s =$ coefficient of static friction

$F_N =$ normal force

Static Friction

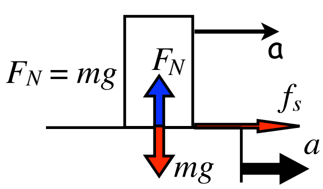
The static friction force between dry, unlubricated surfaces is:

• independent of area of contact for hard surfaces

– not true for deformable surfaces, such as tire rubber.

4.-/38: A cup of coffee sits on a table in a plane (μ_s = 0.30). The plane accelerates. What is the maximum acceleration before the cup starts to slide?

For the cup not to slide: $f_s = ma$ (second law)



$f_s^{max} = \mu_s F_N = \mu_s mg = ma^{max}$ (2nd law)

So, $a^{max} = \mu_s g = 0.3\ g$

$a^{max} = 2.94\ m/s^2$

Accelerations are often quoted as a multiple or fraction of g.

$a^{max} = 0.3\ g$

Kinetic Friction

Occurs when surfaces slide. Friction force opposes the relative motion of the surfaces.

The magnitude of the kinetic friction force is:

$$f_k = \mu_k F_N$$

μ_k = coefficient of kinetic friction

The kinetic friction force is:

- independent of area of contact between the surfaces

- independent of relative speed of the surfaces for small speeds – high speed of sliding may cause heating and a change in the properties of the surfaces.

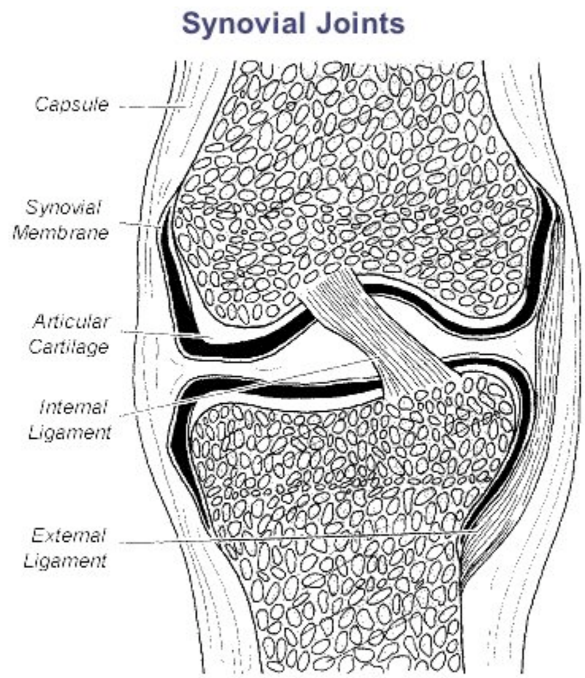
Coefficients of Friction

Materials	Coeff. of Static Friction μ_s	Coeff. of Kinetic Friction μ_k
Steel on Steel	0.74	0.57
Aluminum on Steel	0.61	0.47
Copper on Steel	0.53	0.36
Rubber on Concrete	1.0	0.8
Wood on Wood	0.25-0.5	0.2
Glass on Glass	0.94	0.4
Waxed wood on Wet snow	0.14	0.1
Waxed wood on Dry snow	-	0.04
Metal on Metal (lubricated)	0.15	0.06
Ice on Ice	0.1	0.03
Teflon on Teflon	0.04	0.04
Synovial joints in humans	0.01	0.003

Serway, Physics for Scientists and Engineers

Yahoo search –

The end of two bones which meet to form the joint are covered with articular cartilage, a surface material much like a tread of a tire. Its strength comes from tough fibers called collagen. The joint surface cartilage is well lubricated - more slippery than well-manufactured ball bearings... Its living cells are nourished by joint fluid, called synovial fluid which is also extremely good lubrication.



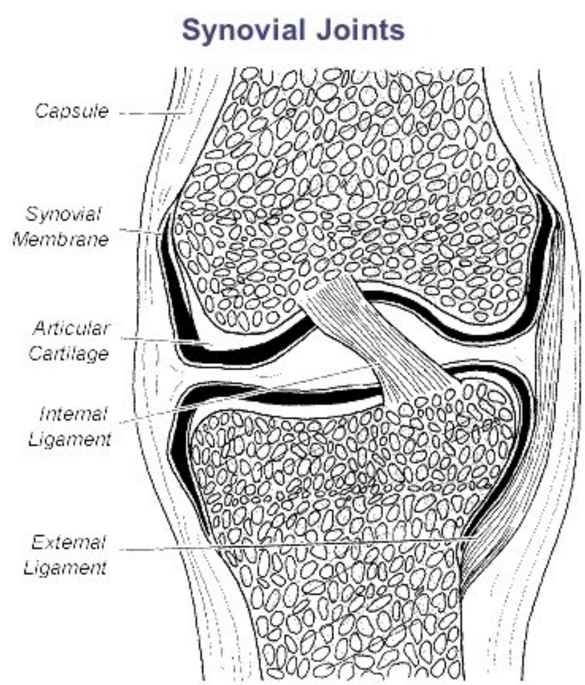
Clickers!

This is:

A) a knee joint

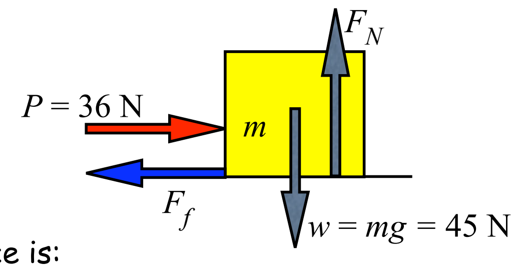
B) an elbow joint

C) some other joint



4.37: A block of weight 45 N rests on a horizontal table. Will the block move and, if so, what is its acceleration?

$\mu_s = 0.650,\ \mu_k = 0.420$



As there are only two forces with vertical components:

$F_N = w = 45\ \text{N}$

The maximum static friction force is:

$F_s = \mu_s F_N = 0.65 \times 45 = 29.25\ \text{N}$

This is less than the force applied, so the block starts sliding.

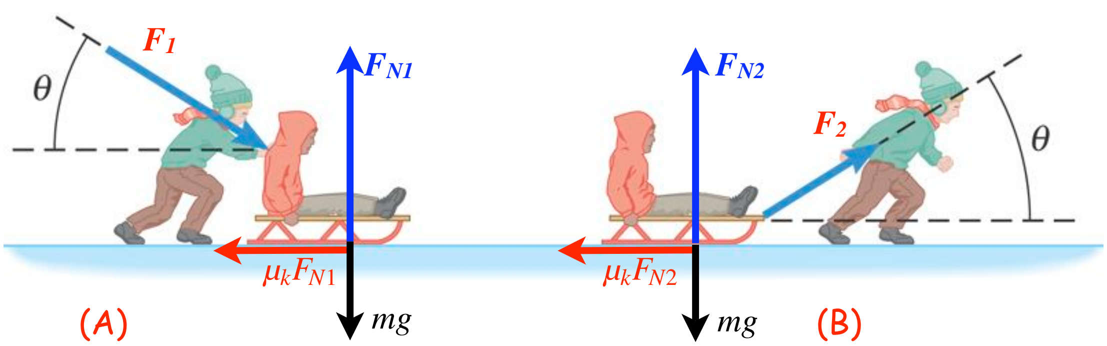
The kinetic friction force is: $F_k = \mu_k F_N = 0.42 \times 45 = 18.9\ \text{N}$

The acceleration is:

$$a = F_{net}/m = (36 - 18.9\ \text{N})/(45/g\ \text{kg}) = 3.72\ \text{m/s}^2$$

Clickers!

4.C18: Which is easier – to pull or to push the sled? Friction is present.

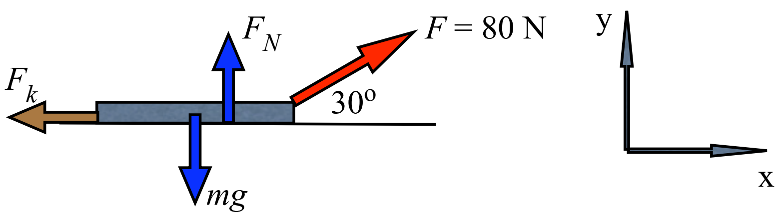


The normal force is **increased** by the downward component of $\mathbf{F_1}$

The normal force is **decreased** by the upward component of $\mathbf{F_2}$

And so the friction force is less when...

4.91/39: A 20 kg sled is pulled across a horizontal surface **at constant speed**.



What is the coefficient of kinetic friction?

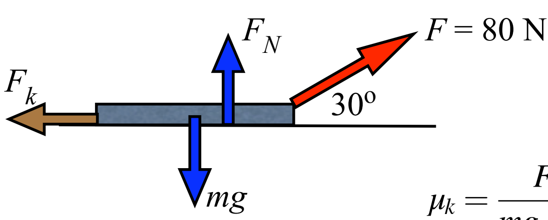
Speed is constant, so net force on sled = 0.

x direction: $F\cos 30° = F_k = \mu_k F_N$ so, $F_N = F\cos 30°/\mu_k$

y direction: $F\sin 30° + F_N = mg$ and, $F_N = mg - F\sin 30°$

$$\text{Therefore, } F_N = \frac{F\cos 30°}{\mu_k} = mg - F\sin 30°$$

$$F_N = \frac{F\cos 30°}{\mu_k} = mg - F\sin 30°$$



$$\mu_k = \frac{F\cos 30°}{mg - F\sin 30°}$$

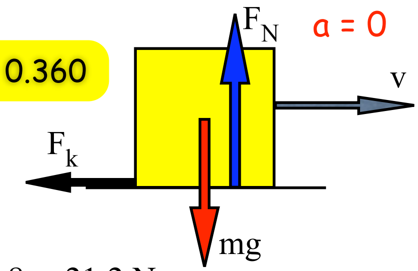
Substitute $F = 80$ N, $m = 20$ kg

$$\mu_k = \frac{80\cos 30°}{20 \times 9.8 - 80\sin 30°} = 0.444$$

4.40: A 6 kg box slides across the floor of an elevator. Find the kinetic frictional force.

(a) Elevator at rest

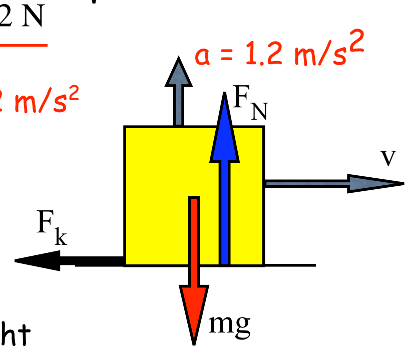
μ_k = 0.360



$F_k = \mu_k F_N$ and $F_N = mg$

So $F_k = \mu_k mg = 0.36 \times 6 \times 9.8 = 21.2$ N

(b) Elevator accelerated upward at 1.2 m/s^2

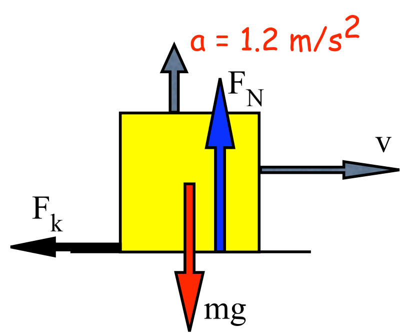


Work out the force needed to accelerate the box upward.

$F_N - mg = ma$

So $F_N = m(g+a)$ = apparent weight

So $F_N = m(g+a)$



$F_k = \mu_k F_N = \mu_k \times m \times (g+a)$

$F_k = 0.36 \times 6 \times (9.8+1.2) = 23.8$ N

(c) Elevator accelerated downward at 1.2 m/s^2

Use a = –1.2 m/s^2 and proceed as above:

$F_k = 0.36 \times 6 \times (9.8-1.2) = 18.6$ N