Final project Format: **10 minutes oral presentation based on Power Point slides**

(you can also use Open Office or Google Documents or similar).

1) Slides will have to be submitted for marking (e-mailed to your section TAs)

2) Final projects are group projects. You work together in tutorial groups (i.e. four persons in each group).

Time: **During your lab period in the week starting on November 19th.**

- Content and marking
- Introduction: Clearly stated problem and result 2 p

Content: Assumptions made to solve the problem
Sources of information
Calculation (estimates)
Result and conclusions 4p

- Quality of the power point presentation 2p
- Quality of the oral presentation (using the power point) 2p
- Quality of answers to the questions 2p

See suggestions of topics at the course website!!

More on dynamics

Friction

- Kinetic friction
- Static friction

---Friction force does not depend on the contact area!

- Rolling friction

Coefficients of friction

Static:

$\mu_S = \max(f_s)/n$

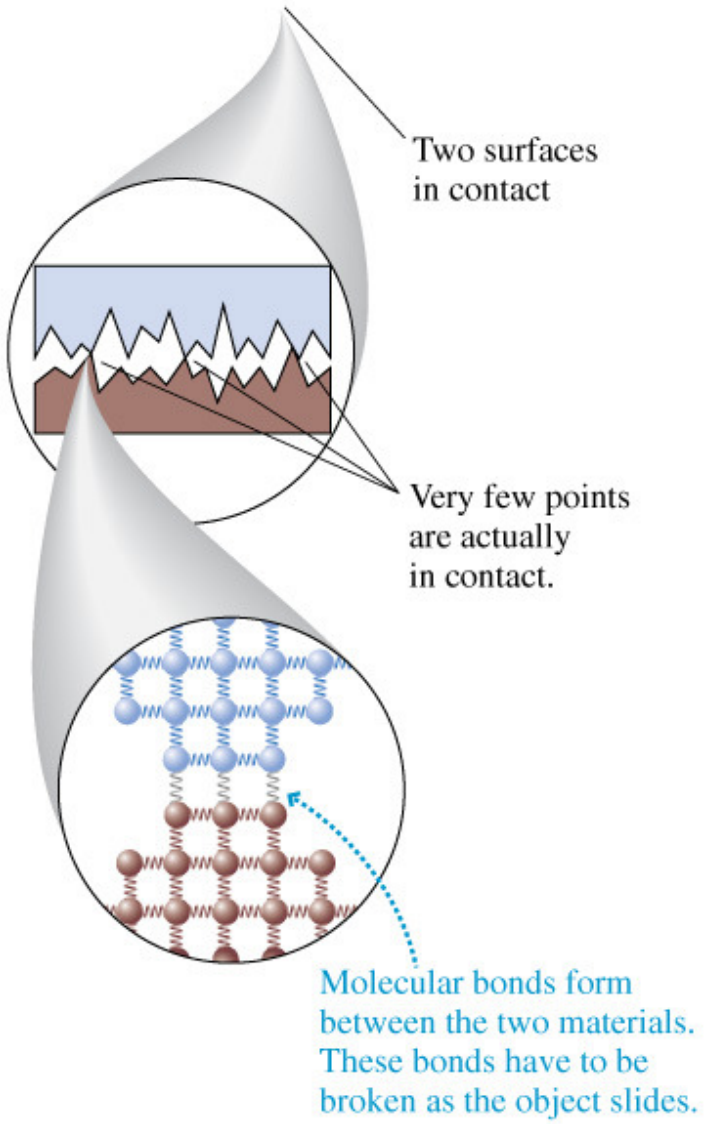
$f_s \leq \mu_S n$

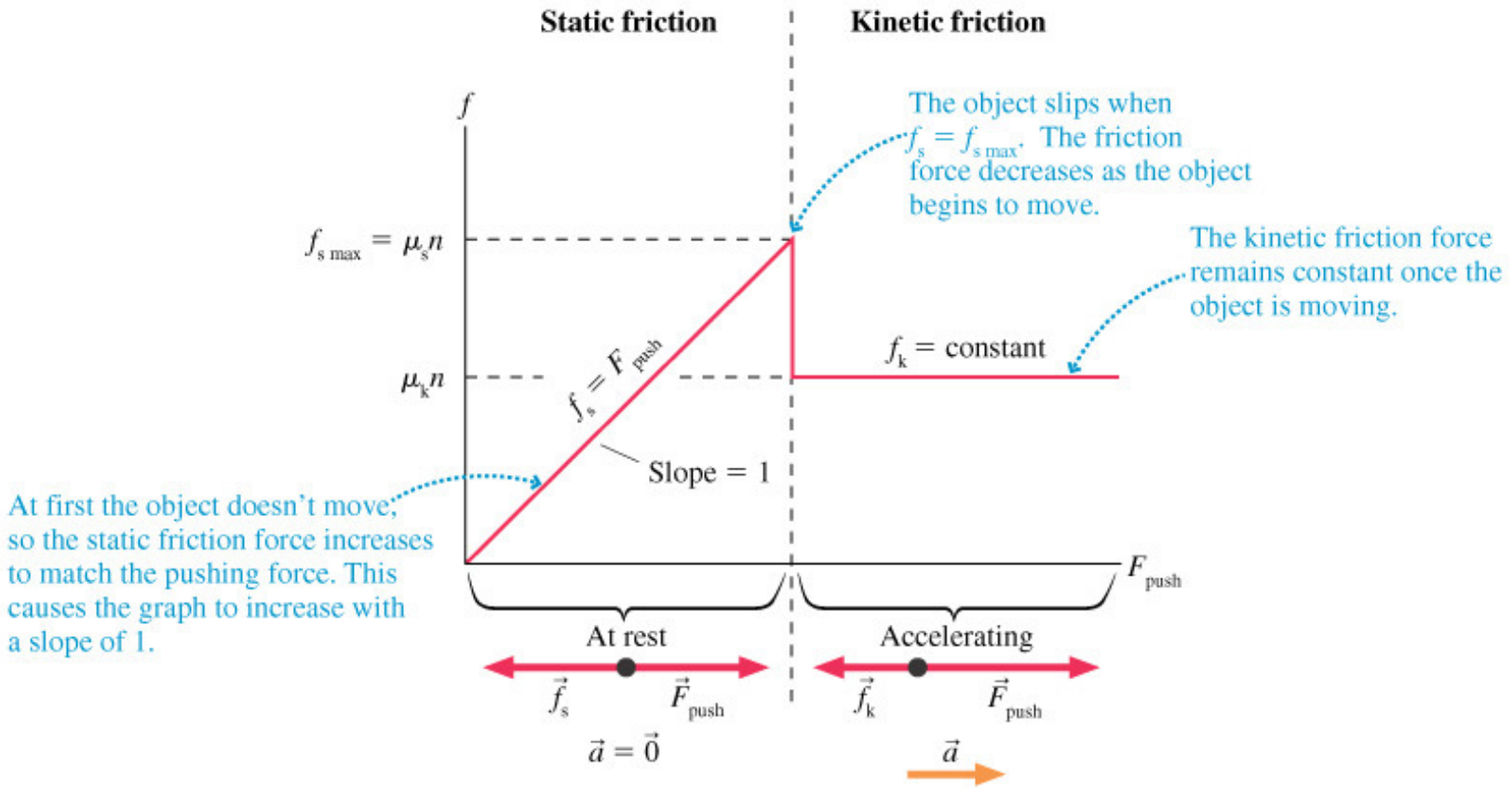
Kinetic:

$\mu_K = f_k/n$

$f_k = \mu_K n,$

$\mu_S > \mu_K$





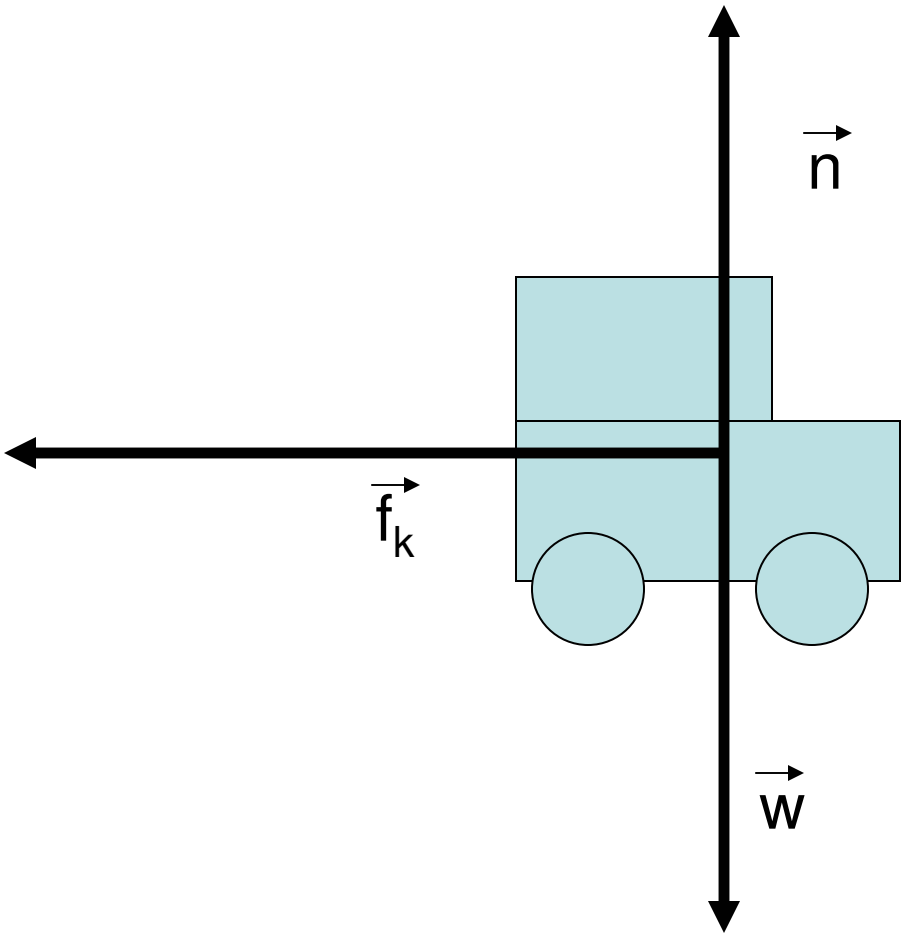
Example: Braking a car

- A car of mass m = 1000 kg driven at 50 km/h suddenly brakes locking the wheels. The coefficient of kinetic friction of the car's tires on the dry asphalt is $\mu_k = 1$. How long will it take for this car to stop and how far it will move after applying the brakes? We ignore the air drag.

Q1. How many forces act on the car in horizontal direction?

Q2. How many forces are acting on the car in the vertical direction?

- Free body diagram of the car:



In the vertical direction:

- $\vec{a}_y = 0$ therefore the net vertical force must be 0:
- $\vec{n} = -\vec{w}$

In the horizontal direction:

- The direction of the friction force is opposite to the velocity!

- $f_k = n\,\mu_K = w\,\mu_K = mg\,\mu_K$

Along the horizontal direction:

- $v_0 = 50$ km/h$= 50 \bullet 1000/3600 = 13.9$m/s
- We choose the direction of v_0 to be positive.

- $a_x = - f_k/m = - g\,\mu_K = - 9.8$m/s^2

- $x = -v_0^2/2a = v_0^2/2g\,\mu_K = 9.7$m

(the time it takes to stop is about 1.4s)

Q3: What if the road surface is wet and $\mu_K = 0.5$ not 1

The distance the car moves before stopping is

1) 9.7m;
2) 2X9.7m;
3) 4.85m;
4) 4X9.7m;

Q4. What would be the braking distance if the initial speed was 100km/h instead of 50km/h and $\mu_K = 0.5$

1) 2 X 9.7m;
2) 4 X 9.7m;
3) 6 X 9.7m;
4) 8 X 9.7m.

Drag force in gases and liquids

Drag force increases with velocity

$D = c A v^2;$

A is the cross-section area of an object;
v is the velocity.
c is the drag coefficient.
(What is the right SI unit for ‘c’?)

For the air, c=1/4 in SI units.

Air drag versus friction

A typical passenger car with rolling friction coefficient 0.02. At which speed does the air drag become bigger than the friction force?

Hint: The cross-section is assumed to be 2m^2; car weight is about 1500kg.