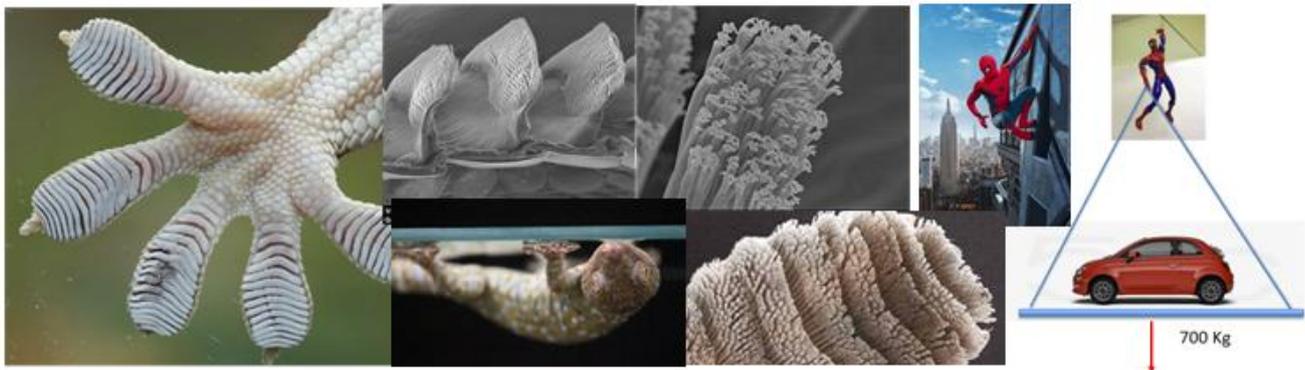




## Nanofriction and Gecko effect



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Friction plays a fundamental role in daily life and in the economy: about a third of the consumption of current world energy resources is due to some type of friction. Tribology is the science that studies friction, lubrication, wear and adhesion between contact surfaces, as well as the various connected phenomena such as fractures or plasticity; for tribology is therefore of fundamental importance what happens to the interface of the materials.

Nanotribology studies the behavior of tribological systems at the nanoscale (dimensions of the order of the nanometer) where the dominant role of atomic / surface forces determines the final behavior of the system; it therefore becomes an ideal area for investigating and understanding atomic and molecular interactions. We will study the properties of an innovative double sided tape, which is inspired by the structure of the gecko's legs. This animal is the most formidable climber that exists, able to climb along mirrored vertical surfaces or walk upside down on the ceiling supporting weights up to 10 times that of his body mass, as if a man of 70 kg were hanging at the ceiling with one hand and in the other hand held a fiat 500: Spiderman!

**DISCLAIMER:** The experiments described in the following document use materials that must be used according to the MSDS specifications and the safety rules in force in schools. The personal safety instructions must be followed as indicated.



## NANOSTRUCTURED SURFACES - Adhesion on inclined plane

### Purpose

- Get familiar with the double-sided Gecko Tape® and test its tribological behavior on different materials
- Measure how the static frictional force varies as the contact surface varies, test friction between a block (Al, MDF ...) and sandpaper
- Measure how the static friction force varies as the contact surface varies between, use the same block materials (Al, MDF ....) and Gecko Tape®
- Suggest hypothesis on the mechanism of adhesion of Gecko Tape®

The study will be articulated in some phases, for each of them there are questions (Q) numbered in progression and highlighted in red, you will have to answer by filling out the "Understanding the phenomena" work card. At the end of the work you will have to deliver the file of the completed form.

The members of the group can compare with each other, look for materials on the handouts provided, on texts, on the internet and, eventually, ask questions to the tutor. The card will be one of the materials to be delivered at the end of the job.

During all the tests you are invited to

- record the measurement conditions, the measurements obtained and any observations, with order and accuracy;
- Document the highlights of the experiments with photos and movies.
- Use the tools and mount the experimental equipment according to the geometry and directions given in compliance with the safety standards. When in doubt reach out to the teachers.



### Activity 1: qualitative adhesion tests

First of all you will have to test, qualitatively and quickly, if the adhesion of the Gecko Tape® changes according to the direction of the force applied in particular for the peeling cases (force perpendicular to the contact surface) or shear (force that acts parallel to the surface contact). The tests can also be done using blocks of different materials: wood, MDF, aluminum.

### Required material

- ✓ gecko tape
- ✓ MDF block
- ✓ aluminum block
- ✓ Adhesive tape
- ✓ Scales
- ✓ Ethyl alcohol and scottex

Clean the surfaces with ethyl alcohol and then dry them: **do not contact alcohol on gecko tape**

### Procedure / questions

**Step 1 observation of the peeling:** Record any observations

Attach the gecko to the MDF block

**Q1.** Try to detach it with a peeling movement; describe the phenomenon by indicating whether the separation is easy or not.

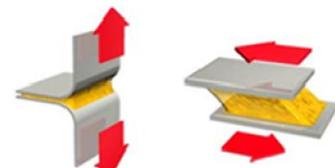


Figure 1 Peeling or shear adhesion



Repeat the test with other materials, perform similar tests with a piece of commercial adhesive tape.

### Step 2 observation of the shear

Attach the gecko to the MDF block

**Q2.** Try to detach it with a shear movement; describe the phenomenon by indicating whether the gap is smooth or not.

Repeat the test with some other materials



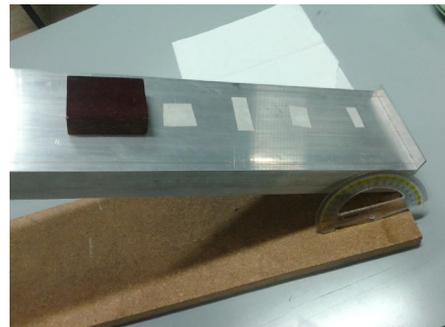
## Activity 2 measurement of the frictional force with the inclined plane

### Required material

- ✓ sandpaper 4 samples of different area

**Attention:** cut the square-shaped samples or in rectangles with not excessively short sides, take care that all the samples have an area smaller than the support surface of the blocks; these must be placed on their larger base area

- ✓ gecko tape® 4 samples with the same area as those of sandpaper
- ✓ double-sided adhesive tape
- ✓ a small piece of aluminum
- ✓ a weight in MDF
- ✓ laboratory inclined plane
- ✓ Protractor (if it is not already part of the plan)
- ✓ Calculator
- ✓ Ethyl alcohol and paper for cleaning



### Procedure / questions

This is a classic friction test: the sample is fixed to the inclined plane and the weight is placed on it, then the plane is inclined to the point of detachment and the corresponding angle is measured, which we will call the separation angle. Repeat measurements are performed on the same sample to obtain a good statistic (at least 20 measurements per sample) and average value, standard deviation, dispersion and absolute error will be calculated.

Repeat everything for the four samples of sandpaper before and Gecko Tape after.

Construct a table of the angles of separation according to the material and the area of the sample.

This is a measure subject to many types of accidental errors, however, has the advantage of being very fast and offering the possibility of testing different aspects with the same experimental apparatus:

- The dependence / independence of the frictional force from the surface area
- The dependence of the frictional force on the material and on the normal force acting on the plane
- Data processing with a statistically significant number of measurements

Students are invited to reflect on the possible causes of systematic error and to eliminate or reduce them by devising optimal operating procedures. Suggestions to be offered to improve precision and reproducibility of the measure will be recorded and will enter the final report as operational procedures. (see question 7)

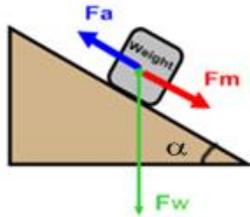


### Suggestions / questions

**Q3.** The chosen weigh should have a height as low as possible to reduce the effects of peeling: reflect on this statement, **evaluate** its veracity and motivate or refute it.

**Q4.** Square or rectangular samples with the long side perpendicular to the driving force are preferred: reflect on this statement, **evaluate** its veracity and motivate or refute it.

**Q5.** Gecko-Tape samples must have areas that can be fully covered by the weight base; this strongly limits the number of significant points (surfaces) and ensures that for the smaller samples the area of the weighing base is only partially covered. You may **find possible accidental errors** introduced into the measurements as a result of the above statement.



**Q6.** List **other accidental** errors that you can imagine

**Q7.** Use the figure of the geometry of the system and the tools and knowledge at your disposal to **write the relationships between the forces involved**

### Data processing

- After measuring the angles  $\alpha$  of the inclined plane at which the known weight detaches, the force weight  $F_w$  it is obtained the driving force  $F_m$ , and consequently the values of  $F_a$  corresponding to the measurements made.
- Evaluate the errors of the measuring instruments, and the overall ones, taking into account the accidental errors related to the structure of the apparatus or to the measurement process.
- Use excel or similar sw to process the measurements by calculating the average value of the frictional force for each area of the sample, then draw the graph that binds the frictional force and the contact surface, reporting error bars. If you are successful, evaluate the dispersion of the measurements on the individual areas by verifying the Gaussian distribution of the values.
- Build a second table where you can compare the results obtained with the sandpaper and those obtained with the Gecko Tape then build a chart that compares the two trends

### Final Report

1. Using word **write a** complete, punctual and concise **technical report** of the various phases of the experience and the results obtained. Also insert images / tables, any significant graphs with appropriate captions.  
If you consider it useful in it, you can include parts of the theoretical understanding and / or theoretical references.  
Conclude with a technical evaluation of the results including any suggestions for improvement.
2. **Build a presentation** (ex power point) to illustrate to your classmates the topics you have studied, both for theoretical and experimental aspects. Organise a plenary exposition of 20 minutes.