The 5th International Young Naturalists' Tournament
Municipal Autonomous Institution of General Education
of the city of Novosibirsk «Gymnasium №12»

Problem № 16
«Paper wrinkles»

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Statement of the problem

When a piece of paper dries after being wet, it can get wrinkled. Investigate and explain this phenomenon.

Hypothesis:

If the press pulls the cellulose fibers in the production of paper, then under the influence of water they diverge from each other, changing the shape of the paper.

Purpose

to research the phenomenon of deformation of paper upon drying after wetting.

Objectives:

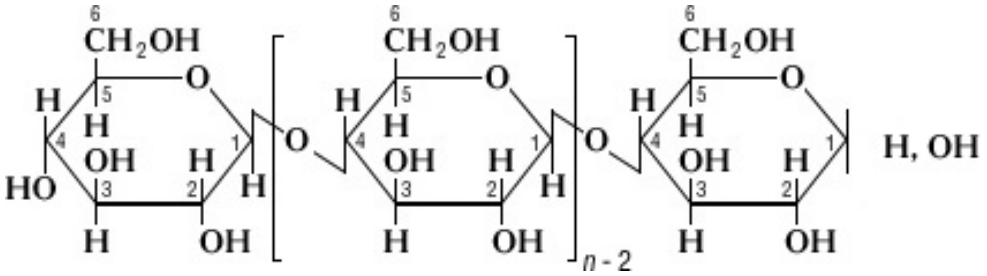
1) Explain from the scientific point of view the process of formation of deformation waves in dried paper;
2) to model the phenomenon of paper deformation of different varieties during drying after wetting in the laboratory conditions;
3) quantify the "wrinkling" of paper of different varieties;
4) establish the dependence of the density of wrinkles on the wetting process;
5) offer the best ways of preventing wrinkles.

Theoretical part of the project

Paper is a material produced by pressing together moist fibres of cellulose pulp and drying them into flexible sheets.

Paper is made from fibrous semi-finished products: wood pulp; Wood chips; Semi-cellulose; Fibers of cotton, flax, hemp, jute.

Structure of the cellulose molecule



Basic stages of paper making

PREPARATION OF RAW MATERIAL UNDER PAPER SORT

FORMATION OF PAPER LEAF

A PAPER LEAF FOLLOWS THREE PRESSES FOR REMOVING REMAINING WATER

PASSAGE OF THE PAPER STRIP BY WITHIN HEAVY WITH HOT BROAD ROLLERS

THROUGH THROUGH COOLED CASES FOR THE APPROPRIATE OF THE NECESSITY OF PLASTICITY

Theoretical part of the project

Why do "wrinkles" appear? When the fibers of cellulose interact with water, the H_2O molecules bind to the cellulose molecules and "spread" them. When the water evaporates, the disturbed structure can not return to its previous state.

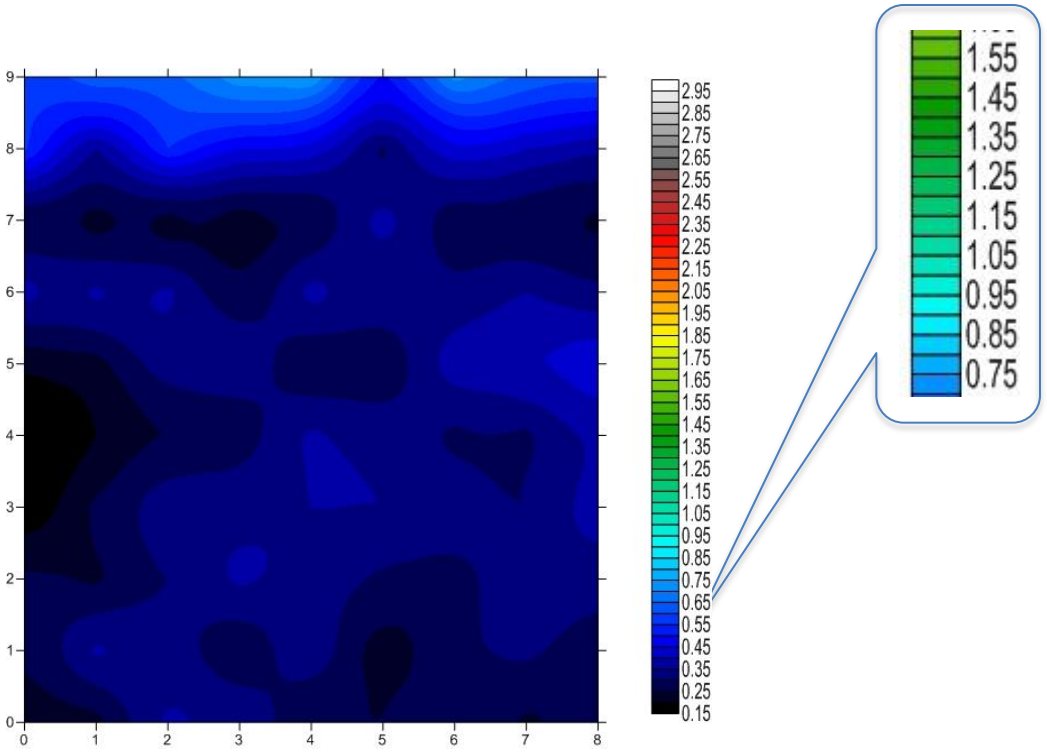
Paper deformation upon drying after interaction with water

Factors affecting the amount of deformation:

- Time of interaction with a liquid;
- Type of fluid;
- Grade of paper;
- Ambient temperature;
- The rate of evaporation of the liquid;
- The paper position when it dries.

Experimental installation

A laser tape measure fixed in a tripod above the horizontal surface of the table. The height of its location during the experiments did not change

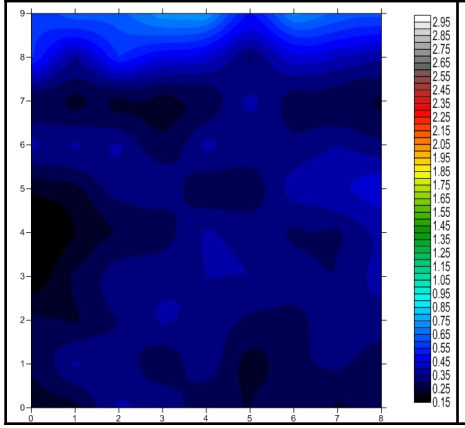
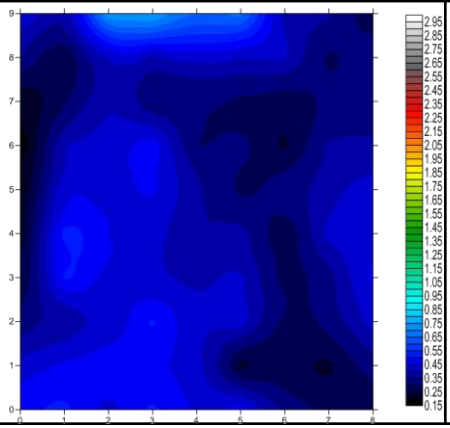
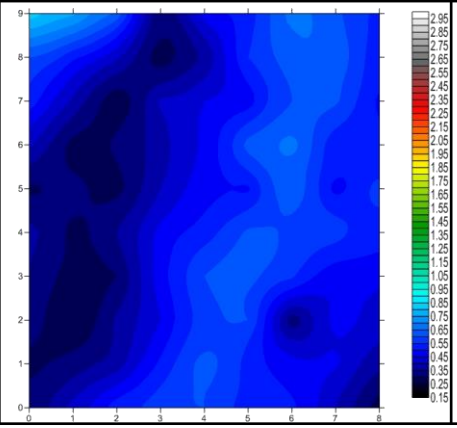
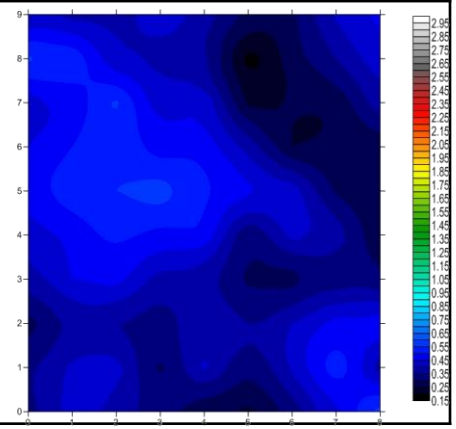


The relief is a piece of paper obtained using the Surfer program. Y, X - the size of a sheet of paper.
The scale shows the distance from the table to the sheet in centimeters.

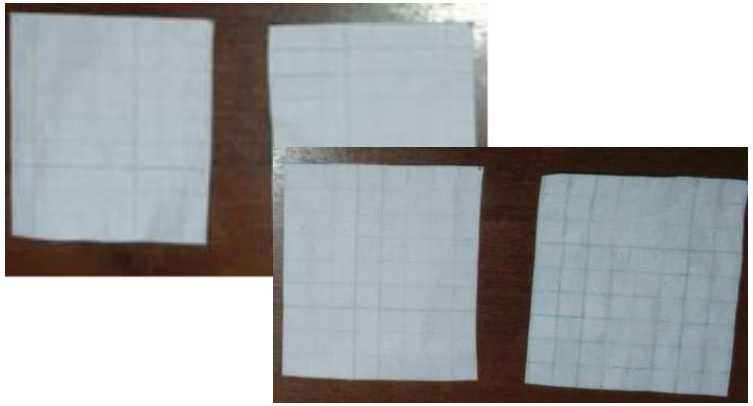
Experiment 1

- **Purpose:** to define the dependence of the value of deformation of the paper on the time of its interaction with the liquid.

Equipment: sheets of office paper 8 * 9cm (lined in a cage of 1 cm), 100 ml of water, stopwatch, laser tape measure, tripod.

10 seconds	*30 seconds*	*60 seconds*	*120 seconds*
			

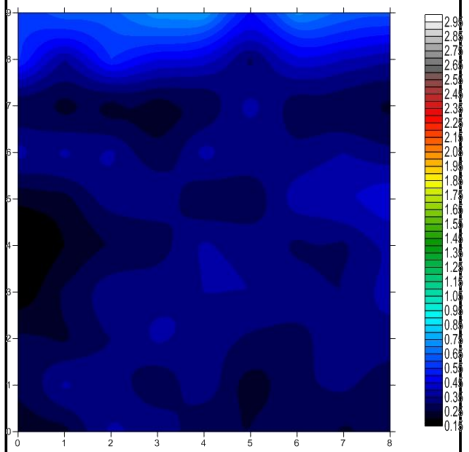
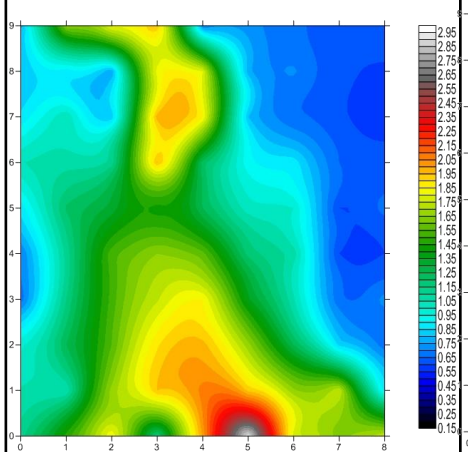
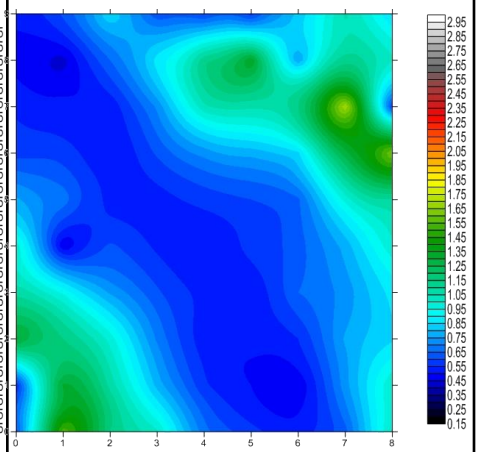
Conclusion: the longer a sheet of paper is in the liquid, the more it deforms, as the time of "build-up" of water molecules in the cellulose structure increases.



Experiment 2

- **Purpose**: to determine the dependence of the deformation on the kind of paper.

Equipment: a sheet of printing paper and toilet paper, a sheet of paper for baking, a cardboard sheet 8 * 9cm (lined in a cage of 1 cm), 100 ml of water, a stopwatch, a laser tape measure, a tripod.

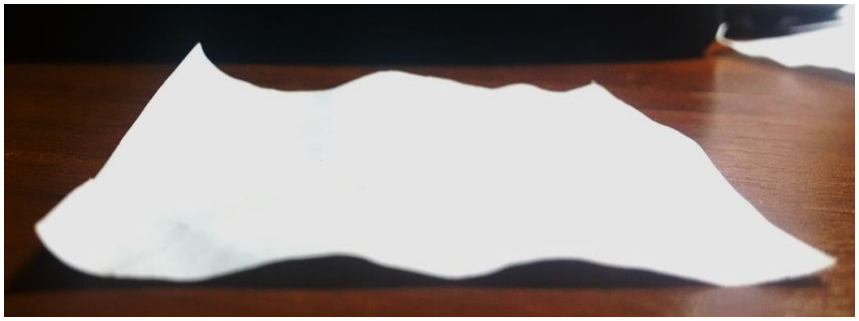
Printing paper	*Toilet paper*	*Paper for baking*	*Cardboard sheet*
	 Toilet paper almost dissolved in water, and when you try to remove it from water, the paper tore.		

Conclusion: the amount of deformation depends on the type of paper, in particular on the density, the features of manufacture and the kind of raw materials.

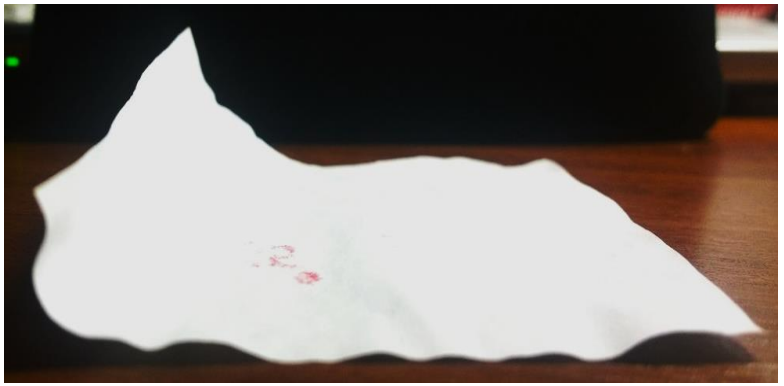
Experiment 3

- **Purpose:** to define the dependence of the deformation on the environmentally temperature.

Equipment: sheets of paper for the printer in size 10 * 10cm, 10 ml of water.



Room temperature, 24ºC



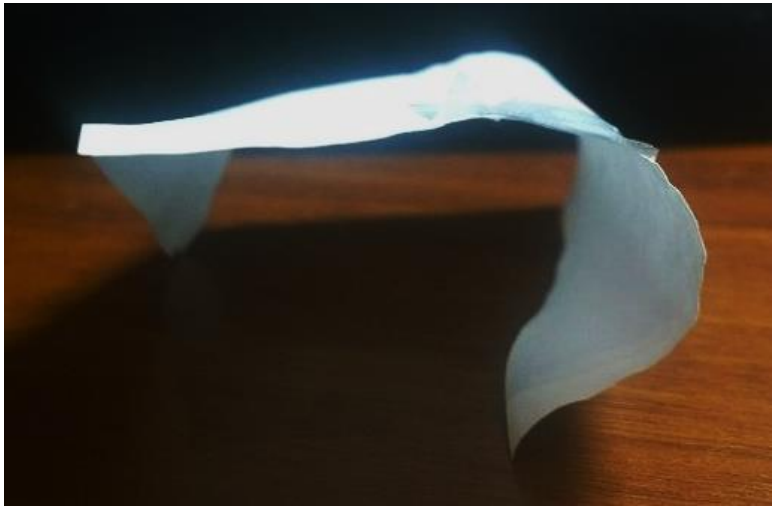
Temperature on the radiator heating, 50ºC

•Conclusion: the higher the environmentally temperature, the evaporation of water occurs faster, which leads to the greatest deformation of the sheet. The cellulose fibers "shrink" as the temperature rises, returning to their original structure.

Experiment 4

- **Purpose:** to define the dependence of the deformation on the position of a sheet of paper.

Equipment: sheets of paper for a printer (offset) with a size of 10 * 10 cm, 10 ml of water, a tripod, a foot with a coupling, a press.



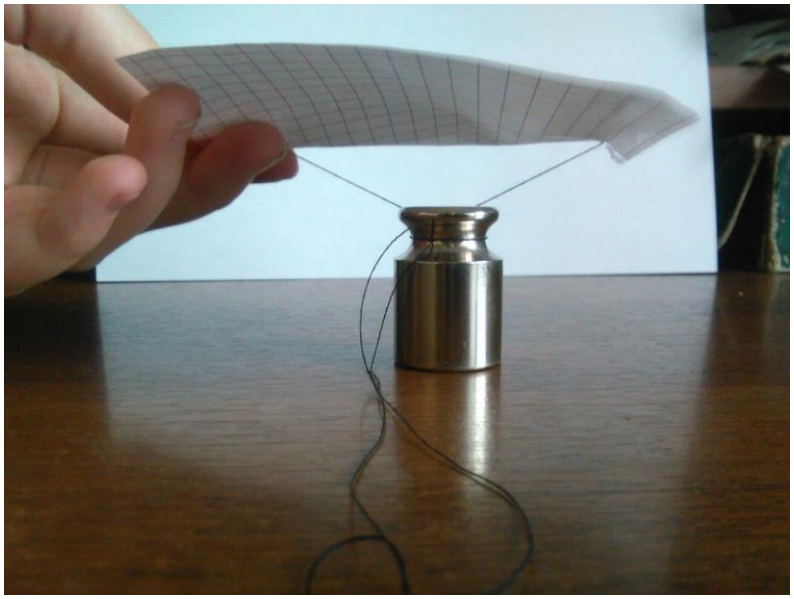
In the photo on the left is a sheet dried under the press of 20 kilograms, on the right - dried "in free" condition, suspended on a tripod

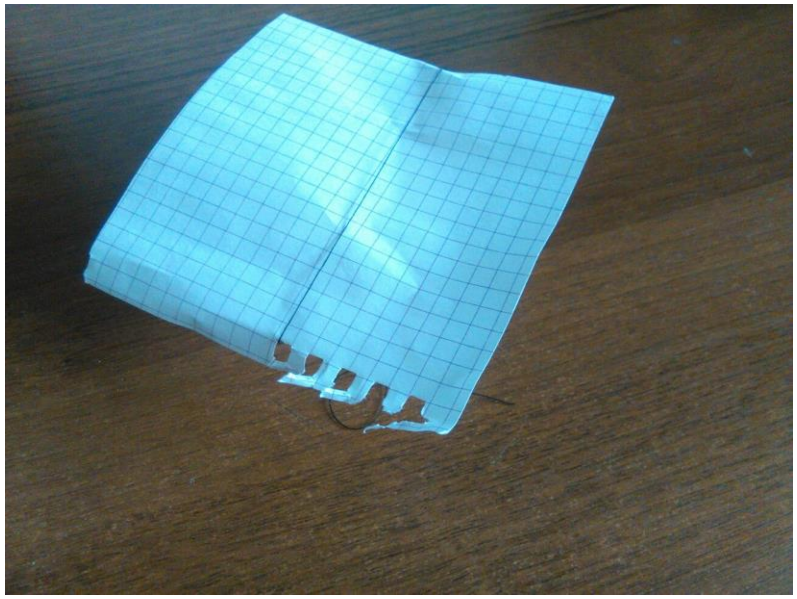
•Conclusion: the position of a sheet of paper during drying has a significant effect on the amount of deformation. In the "free position" on the tripod, the area of evaporation of the liquid increases and the cellulose fibers begin to fold. When dried on a smooth surface, the water molecules interact not only with the paper but also with the table, preventing the fibers from assuming the usual shape.

Experiment 5

- **Purpose:** to define the dependence of the sheet density on its quality and time in water.

Equipment: samples from the experiment 1 and 2 8 * 9cm, weights 100gr (2pcs), 50gr (2pcs), 20gr (4pcs), 10gr (2pcs), 5gr (2pcs), 2gr (4pcs), 25cm thread (6pcs).





The photo shows a installation used to measure the strength of paper

Experiment 6

The result of the strength measurement is shown in the table:

	Experiment 1				*Experiment 2*		
The weight of the load at which the sample was torn, g	1 sheet, 10 seconds	2 sheet, 30 seconds	3 sheet, 60 seconds	4 sheet, 120 seconds	Cardboard sheet	Office paper	Paper for baking
	320	290	270	190	485	320	110

•Conclusion: The time the paper is in the water before drying significantly affects the strength of the paper, and the quality of the paper also affects the strength. The less paper is in the water and the denser it is, the stronger it is.

Conclusion

Thus, during the experimental part of the study, the process of deformation of the paper was observed.

The amount of deformation was measured quantitatively, and it depends on:

- time of interaction of paper and liquid;
- the kind of paper;
- temperature of the environment;
- the position of the paper in the air space when it dries.

Sources information

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