Spider's web

Condition of the problem:

Spider's thread looks like a string of pearls. What is the reason for this? Make experiments to investigate the relevant parameters.

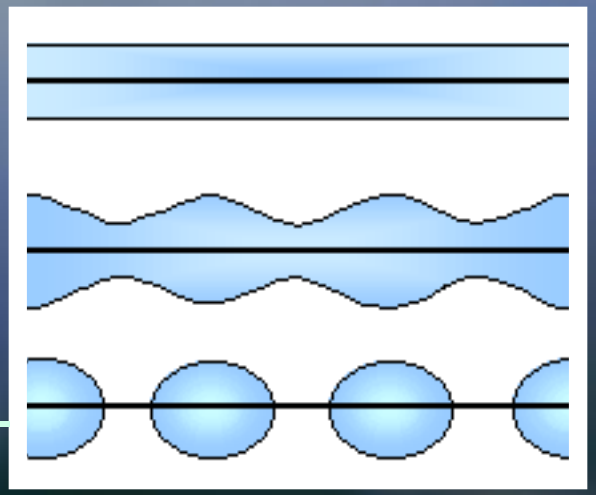
Spider's web like beads.

- Spider’s web looks like beads itself if watch on it through the microscope.

- Web is similar to thread of pearls with drops of dew on it.

Web's strucrture.

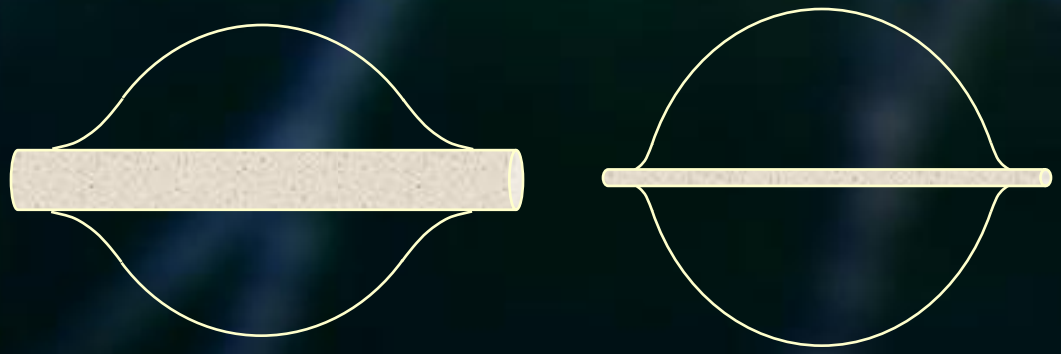
Web through the microscope.



Drops forming from a liquid cylinder.

Every sistem tends to the state with minimum energy.

$$E_s = \sigma S$$

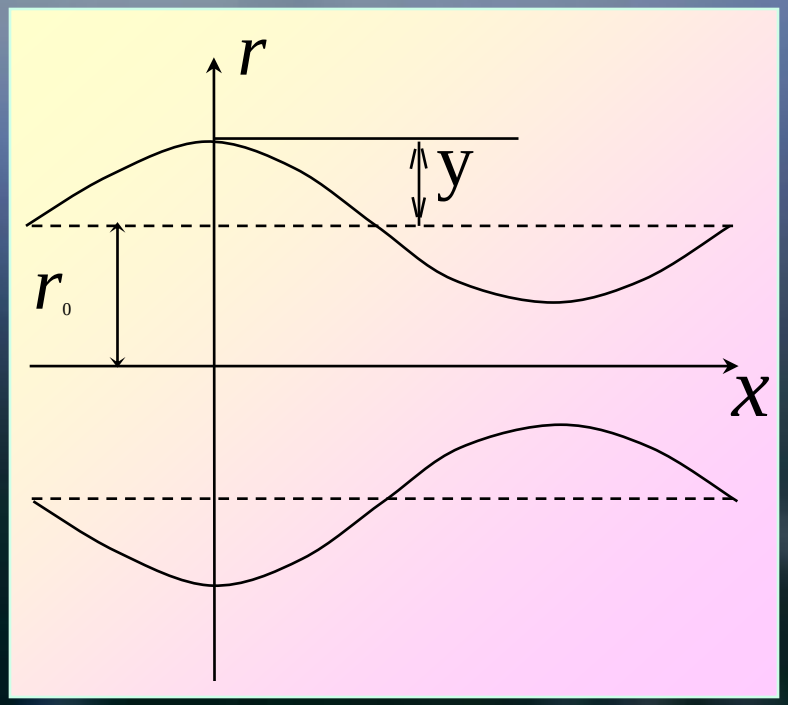


Theoretical model.

$$r(x,t) = r_0 + y(x,t)$$

$$y(x,t) = A(t)\cos\frac{2\pi}{\lambda}x = ae^{\alpha t}\cos\frac{2\pi}{\lambda}x$$

Where **t**-time;
a-the initial amplitude;
α-coefficient,which characterize damping or growth of the wave.



$$\rho\frac{\partial^2 y}{\partial t^2} = -k\frac{\Delta p}{\lambda}$$

ρ-density;
$\partial^2 y/\partial t^2$-acceleration of unit volume

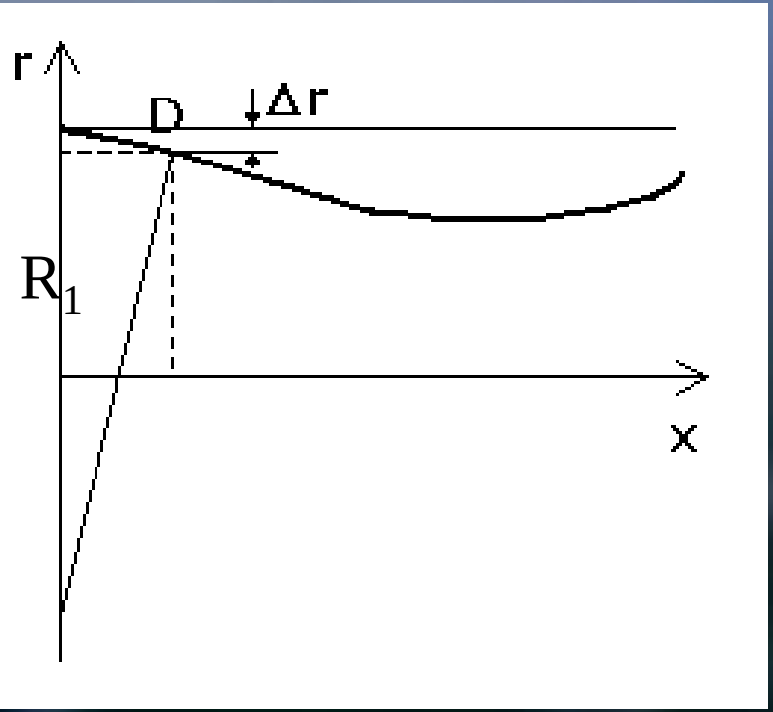
$$F = -\partial p/\partial r;$$
$$\partial p/\partial r = k\Delta p/\lambda$$

Δp-pressure difference.

Radius of curvature.

$$P - P_a = \sigma(1/R_1 + 1/R_2)$$

P_a- the atmospheric pressure;
σ- surface tension coefficient;
R_1 and R_2- main radiuses of curvature.



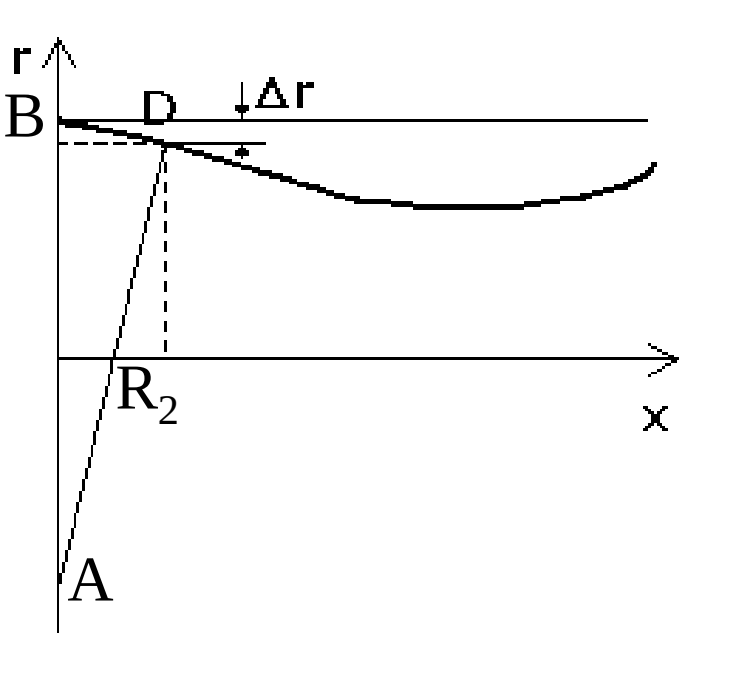
$$\frac{1}{R_1} = \frac{1}{r(0,t)} = \frac{1}{r_0 + A} \approx \frac{1}{r_0}\left(1 - \frac{A}{r_0}\right)$$

Radius of curvature.

$$\Delta r = r(0,t) - r(x,t) = A\left(1 - \cos\frac{2\pi}{\lambda}x\right)$$

$$\cos\frac{2\pi}{\lambda}x \approx 1 - \left(\frac{2\pi}{\lambda}\right)^2 x^2/2$$

$$\Delta r = A\left(\frac{2\pi}{\lambda}\right)^2 x^2/2$$



From triangle ABD it follows:

$$2R_2\Delta r = x^2$$

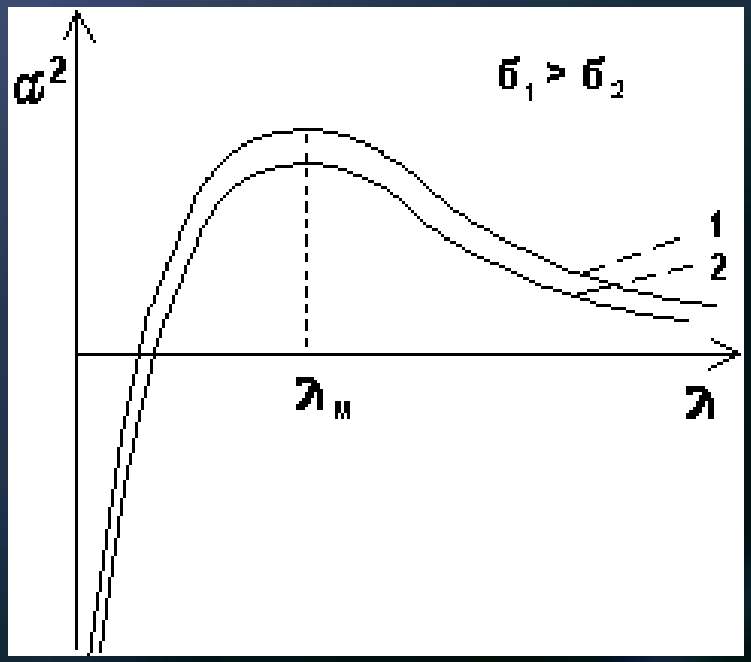
$$\boxed{\frac{1}{R_2} = A\left(\frac{2\pi}{\lambda}\right)^2}$$

Condition of instability.

$$\Delta p = P - P_0 = \sigma A\left(\left(\frac{2\pi}{\lambda}\right)^2 - \frac{1}{r_0^{\,2}}\right)$$ **-change of pressure.**

$$\partial^2 y / \partial t^2 = \alpha^2 A$$

$$\boxed{\alpha^2 = \frac{k\sigma}{\rho r_0^{\,2}\lambda}\left(1 - \left(\frac{2\pi r_0}{\lambda}\right)^2\right)}$$



Condition of instability of liquid cylinder:

$$\lambda > 2\pi r_0$$

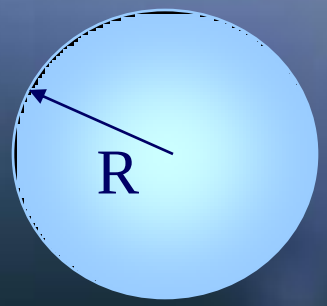
Wavelength with the highest growth speed:

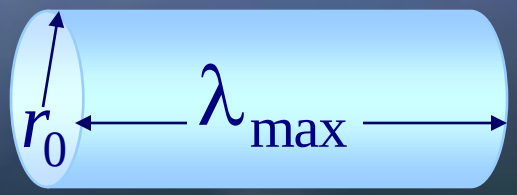
$$\lambda_{\max} = 2\sqrt{3}\pi r_0$$

Drops sizes.

$$R_{Drop} = \left(\frac{3}{4} r_0^2 \lambda_{\max} \right)^{1/3}$$

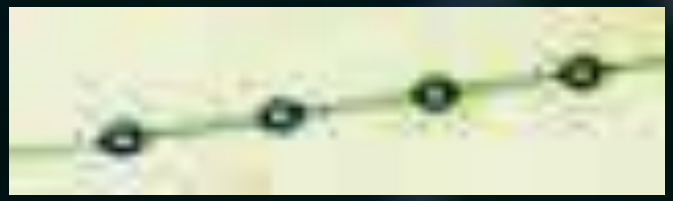
$$R_D = \frac{\lambda_{\max}}{2} \left(\frac{1}{2\pi^2} \right)^{1/3}$$



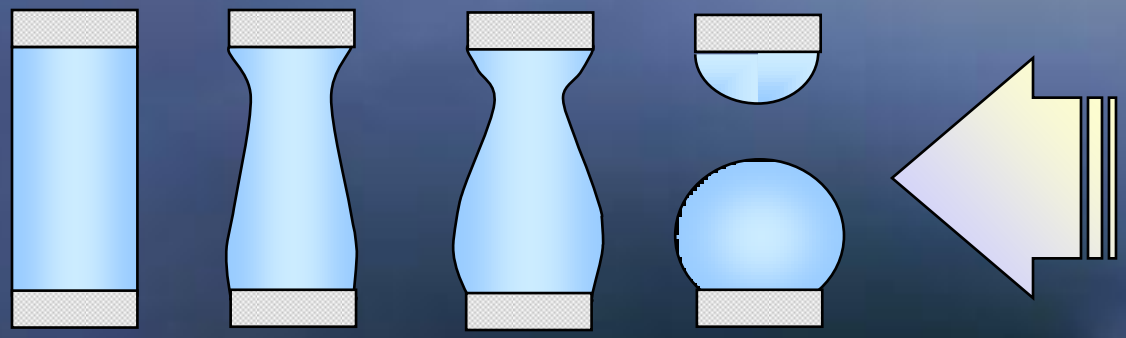


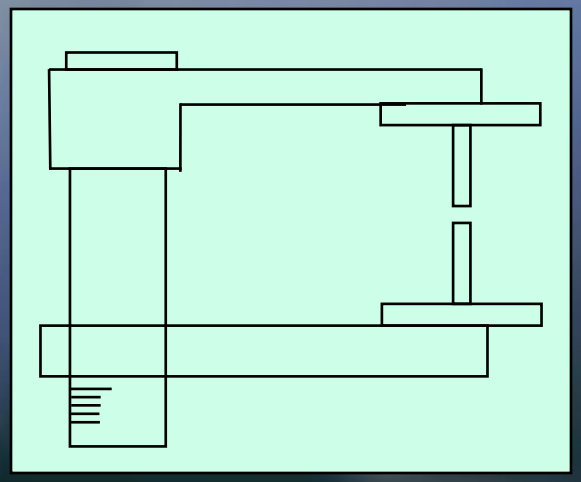
Theory:

Nature sizes:



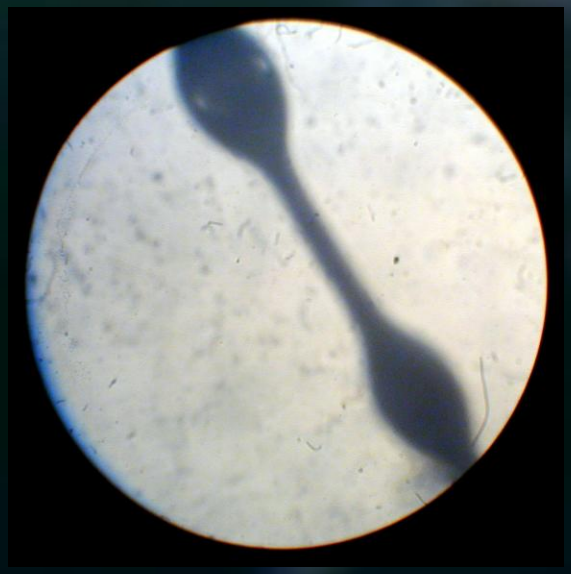
Experimental model.





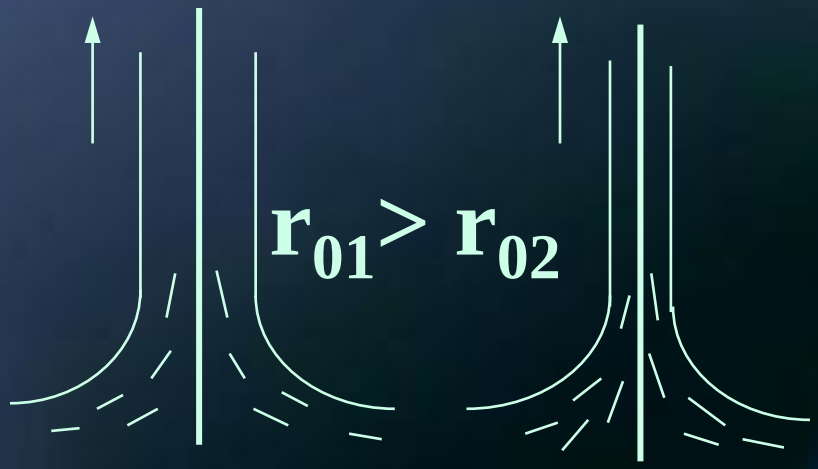
When length of the cylinder is more than three its diameters it begins disintegrate on two drops.

A hair with oil



Influence of different parameters.

Drops of nitrolaquer on a hair



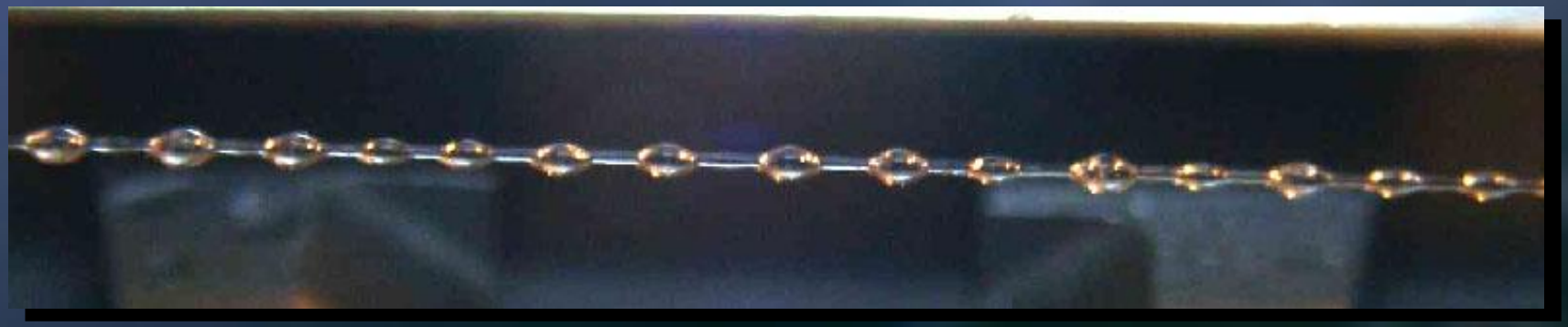
More viscous liquid

Less viscous liquid

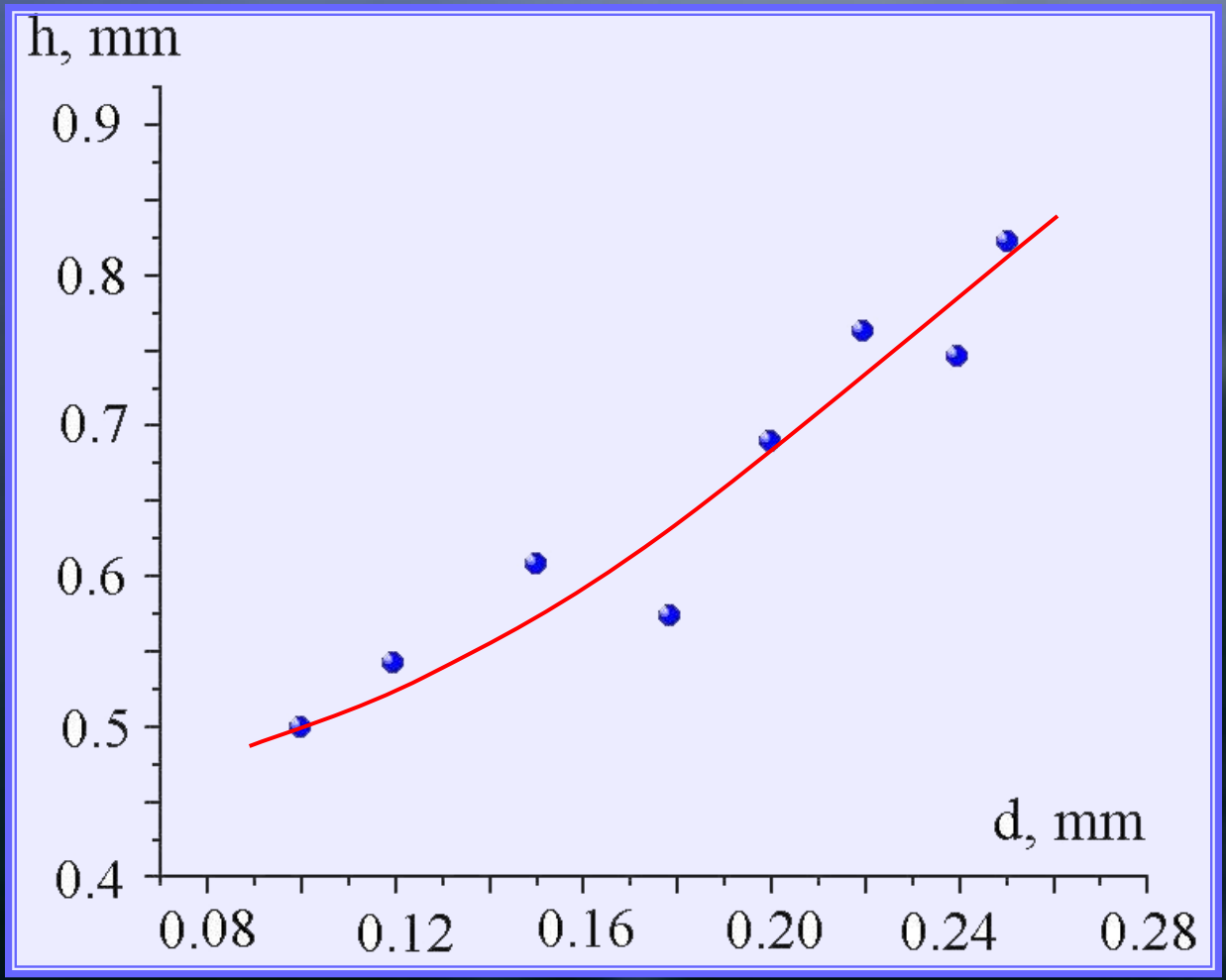
$$\lambda_{max} = 2\sqrt{3}\pi r_0$$

Threads with different diameters.

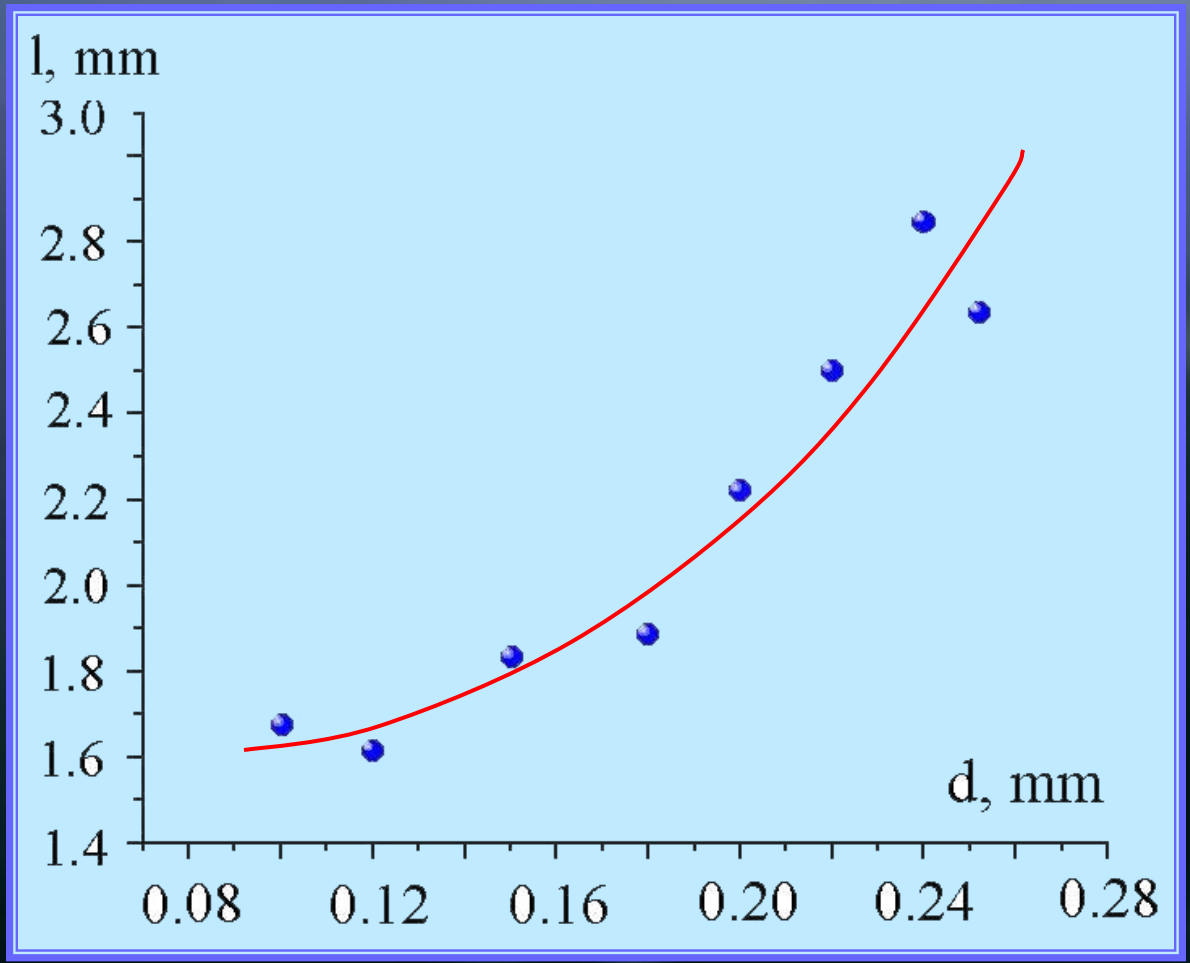
Fishing-line and pitch



The dependence of drop heigth on thread diameter.



The dependence of the distance between drops on thread diameter.



The process of drop forming.

1

2

3

4

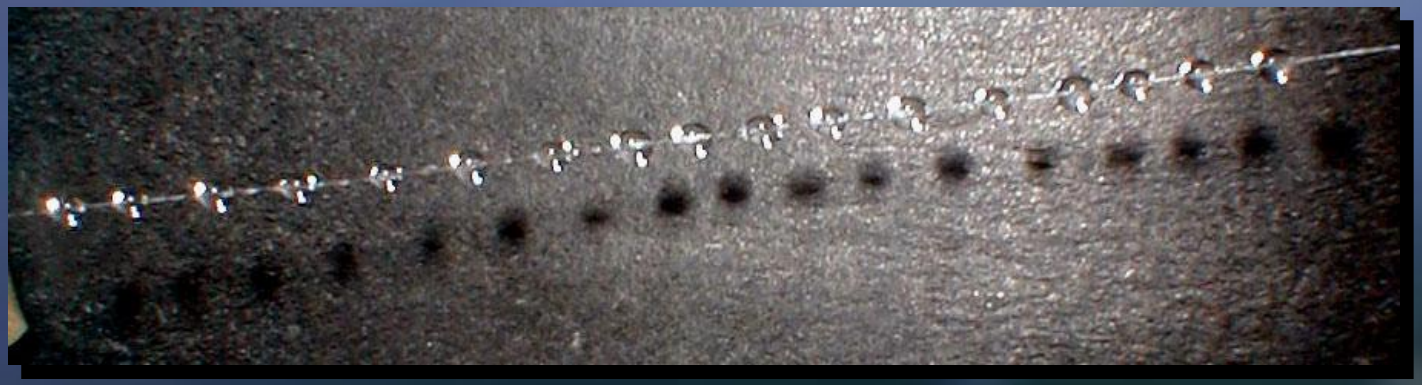
5

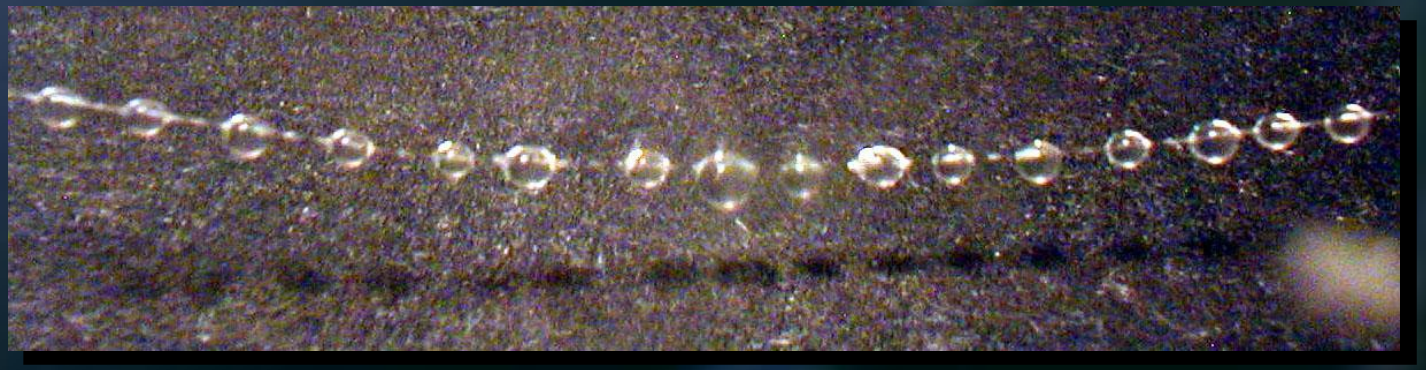
Condensation.

$$\varphi = \frac{p_{w.v.}}{p_{s.}} 100\%$$

Condensation begins from the blobs of spider's web, which serve as the centres of condensation.

Dewfall.





Flashes on the drop.

Conclusion.

- Simularity between web structure and beads.
- Theoretical model.
- Experimental model.
- Drop sizes. Influence of different parameters
- The process of drop forming
- Condencation and dewfall
- Flashes on the drops.