17th IYPT
AUSTRALIA - Brisbane
24th June to 1st July

- **Brazilian team**

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Problem 4 – Dusty Blot

- *“Describe and explain the dynamics of the patterns you observe when some dry dust (e.g. coffee powder or flour) is poured onto a water surface. Study the dependence of the observed phenomena on the relevamt parameters.”*

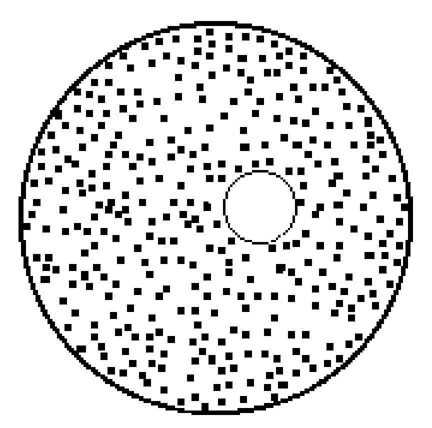
Introduction - History

- Robert Brown → *Brownian Motion*



Theory – Brownian Motion

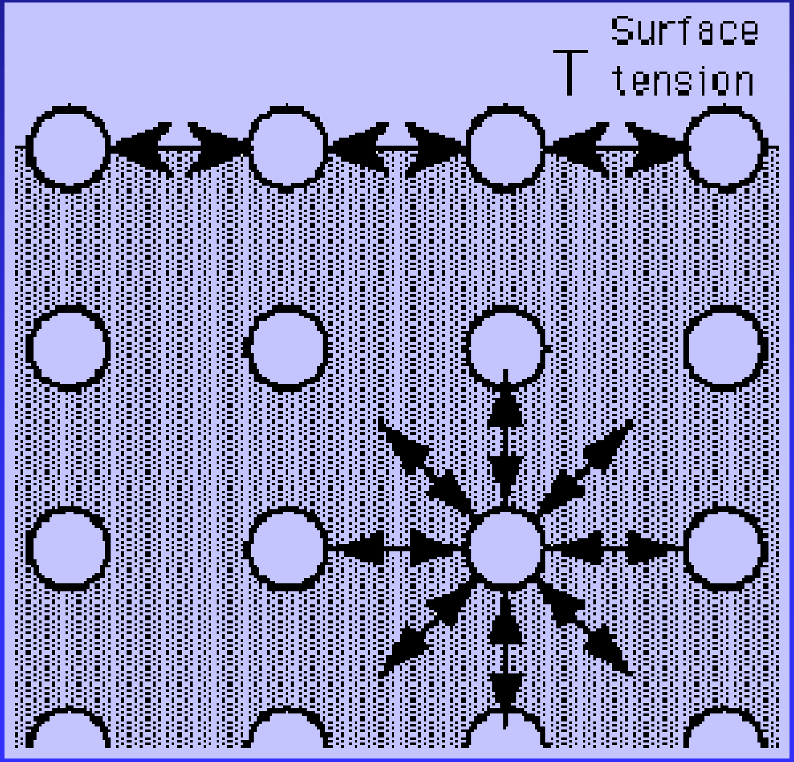
- When we observe a colloid (dispersion where the diameter of the dispersed particle – micela – is between 1 and 100 nanometers) in an ultramicroscopic, we realize that particles aren't stopped, but in an incessant and disordered movement. This movement is explained by the collisions between the fluid's molecules and the particles in suspension.



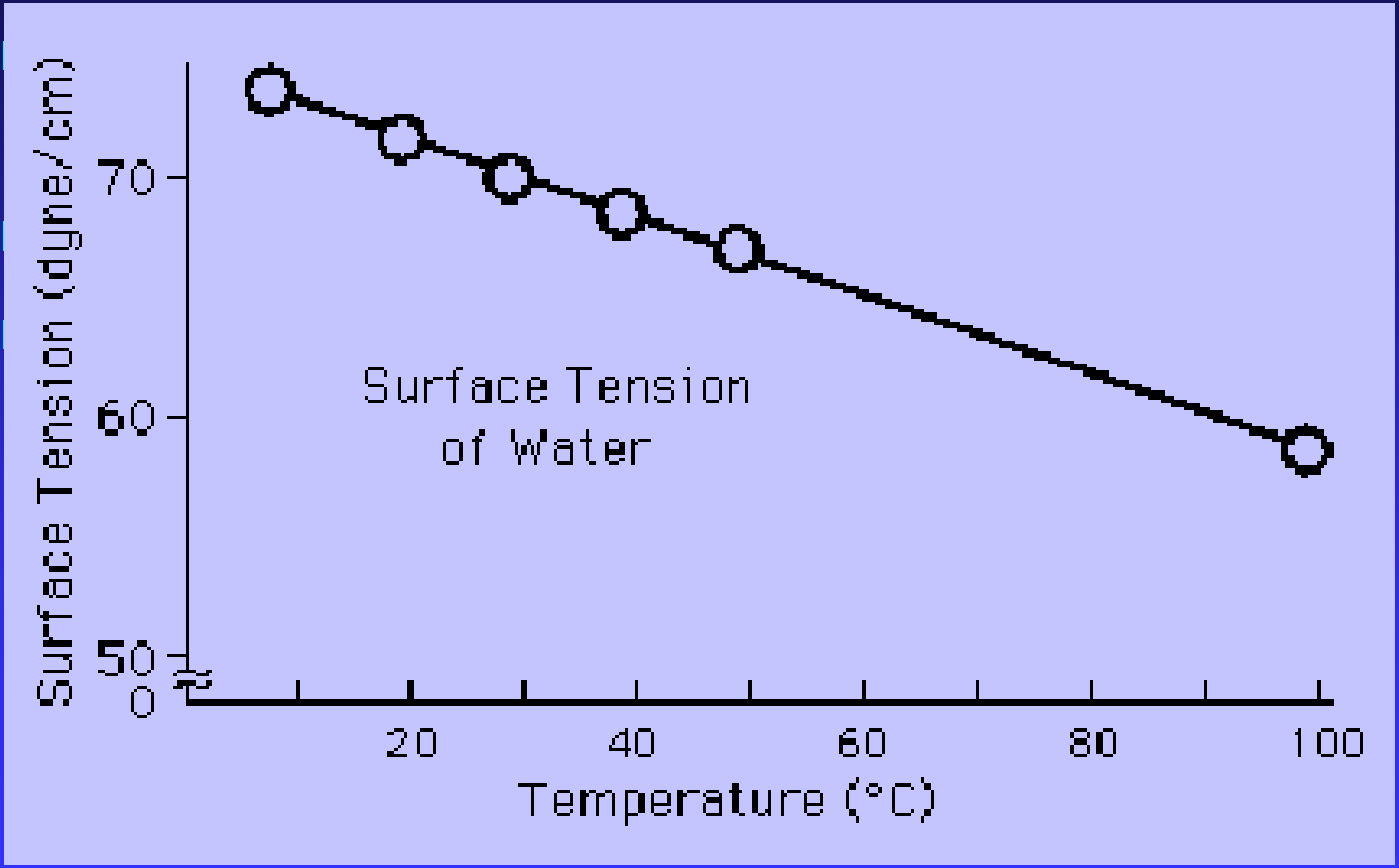
How the moviment of the grains is caused by the collisions of the liquid's molecules.

Theory – Surface Tension

- Water => hydrogen bounds
- Free energy on the surface
- Extended membrane
- $\gamma = F/2.L$



Theory - Surface Tension



Experience

- **Materials:**
- Water
- Milk
- Flour
- Talc
- Glass vessel
- Microscope
- Lamina

Experience - Macroscopic

- We filled the glass vessel with water and we poured flour through the bolter on the water surface. We observed that the particles of flour became diffused. We did the same proceeding with the talc, and we observed the same phenomenon.

Experience - Macroscopic

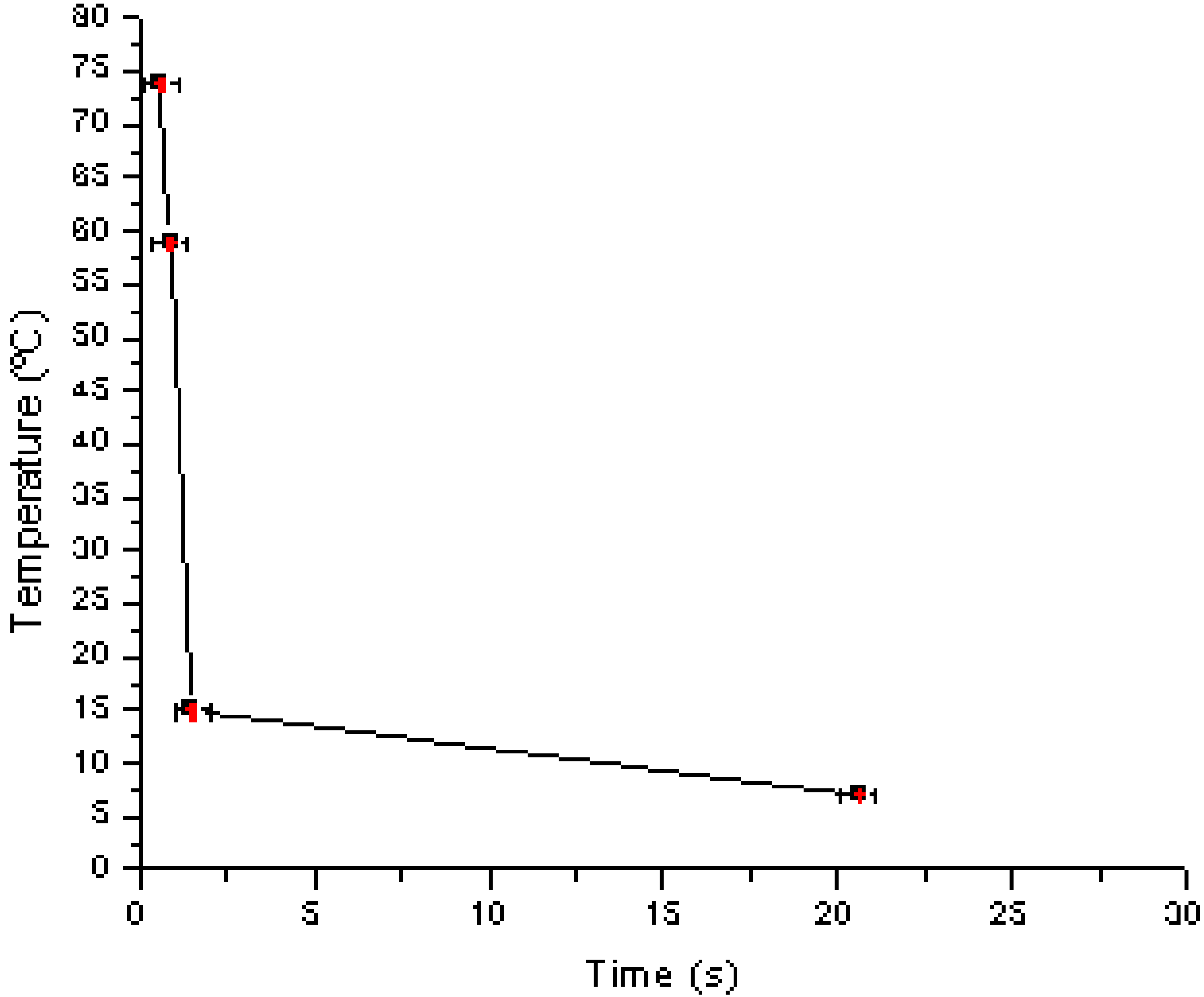
- Different temperatures: different surface tensions
- Time to arrive at the edge of the vessel

Diameter of the vessel: 15 cm
150 ml of water

Experience - Macroscopic

- Flour

Temperature	Time
(7.0 ± 0.5) ºC	(20.63 ± 0.05) s
(15.0 ± 0.5) ºC	(1.48 ± 0.05) s
(59.0 ± 0.5) ºC	(0.86 ± 0.05) s
(74.0 ± 0.5) ºC	(0.61 ± 0.05) s

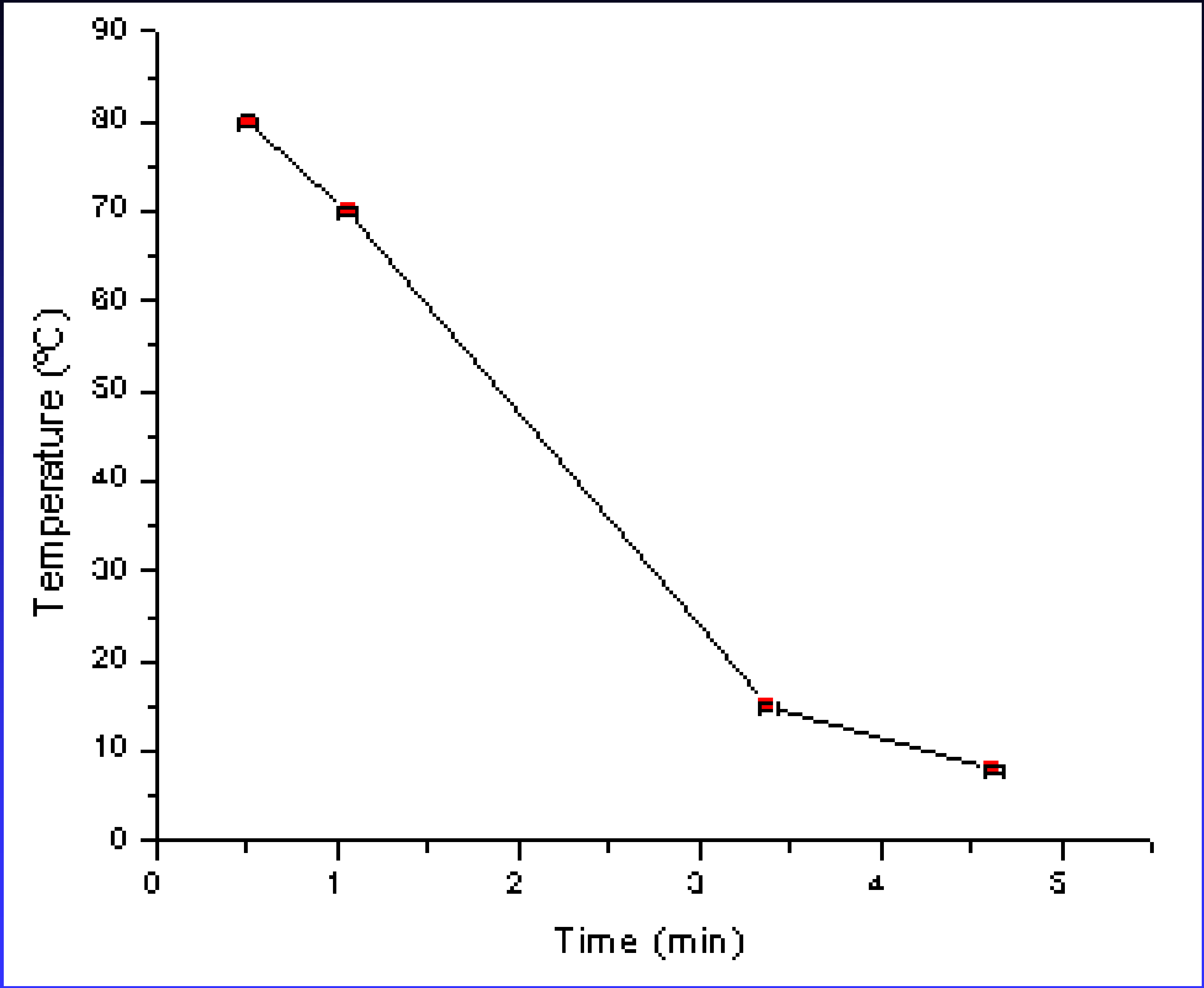


Temperature (°C)
Time (s)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80

Experience - Macroscopic

- Talc:

Temperature	Time
(8 ± 0.5) ºC	(278.12 ± 0.05) s
(15± 0.5) ºC	(202.97 ± 0.05) s
(70 ± 0.5) ºC	(63.59 ± 0.05) s
(80± 0.5) ºC	(30.78s ± 0.05) s



90
80
70
60
50
40
30
20
10
0
Temperature (°C)
0
1
2
3
4
5
Time (min)

Experience - Microscopic

- Problem: size and mass of dust particles

- Diffraction grating:
- Milk < 10µm
- Talc > 10µm and < 70µm
- Flour > 30µm and < 70µm

- Solution: observation of the movement of the milk’s drops dissolved in the water

video

Experience - Microscopic

- Comparison between the movement of the milk’s drops and the moviment of the flour, coffee powder and the talc in the water.

- Flour

vídeo

- Talc

vídeo

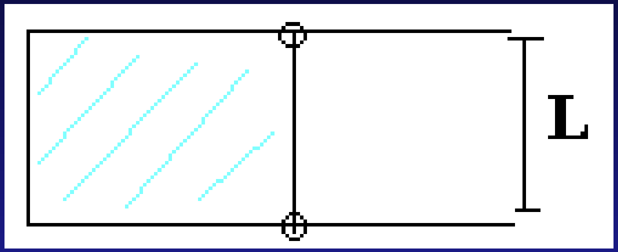
Conclusions

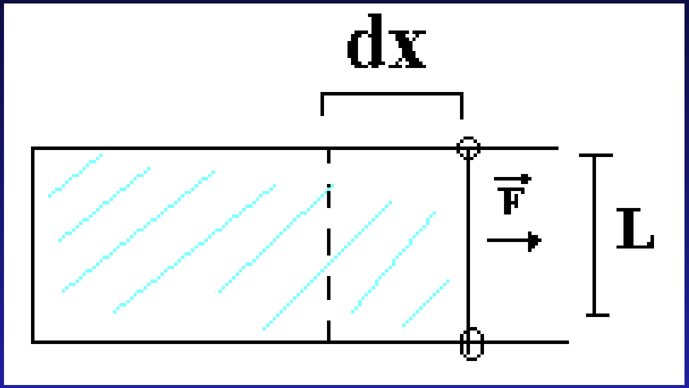
- In the movement of the milk drops, we could observe that the drops was in a incessant motion. This motion was the Brownian Motion.
- When we compared this motion with the motion of the dust particles, we could notice that the motion is totally different, and all the particles was arrested in the same direction.

Conclusions

- The dust particles stay on the water surface, because of the water surface tension and they are arrested all together through the fluid.
- The higher the temperature, the faster the movement; so, the lower the surface tension, the faster the movement.

- Considering a liquid pellicle extended on a wire:





- If we pull the wire thread a distance dx, so, there will be na increase in the pellicle area that we will indicate for dA. Then:
- $dA = L.dx$
- γ is energy for unity of area, it will increase too:
- $dE = \gamma .dA$

- As the energy increased, to do this movement a force (F) perpendicular to the thread of wire was needed, an exerternal agent did a work F.dx. Then:
- $F.dx = \gamma .dA$
- There is a force that the pellicle does on the wire to come it back to reduce the sistem energy: this is the surface tension.
- $\gamma = F/2.L$