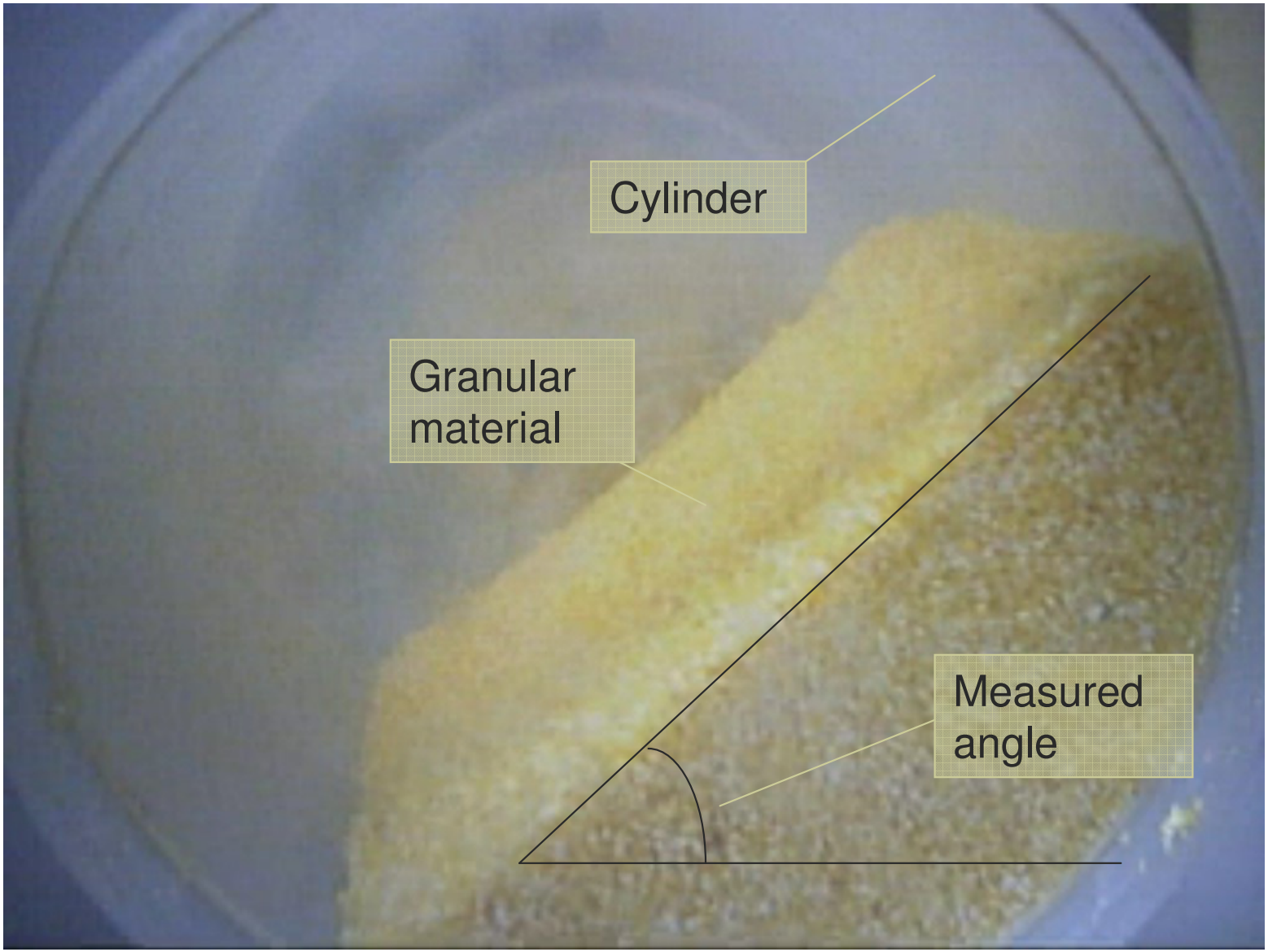
Avalanche

Problem 03.

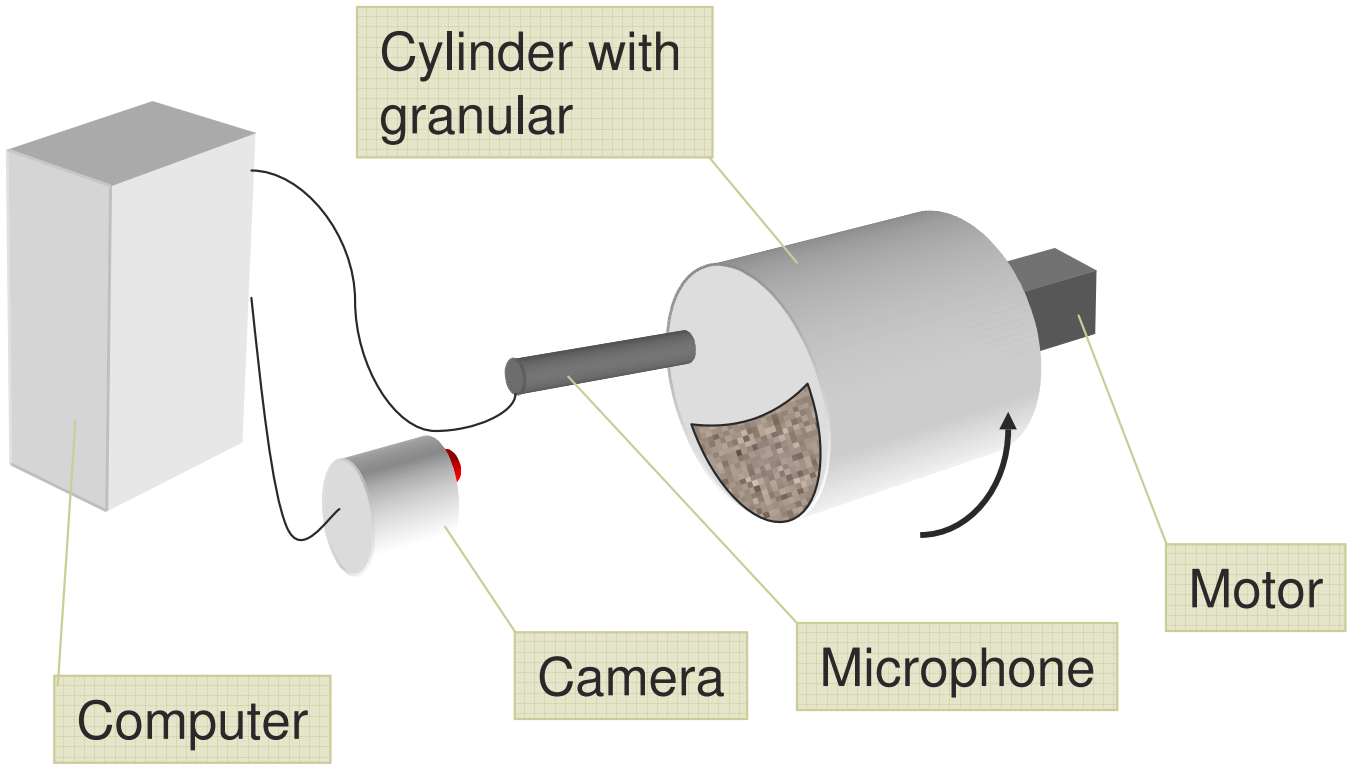
Problem

- Under what conditions may an avalanche occur ? Investigate this phenomena experimentally.

Experiment



Experimental setup cont.



Conducting the experiment

- Granular is rotated in a cylinder
- Recording granular behavior with digital camera and microphone to a computer
- Further analysis of data recorded to find the marginal angle of slipping

Conducting the experiment cont.

- Experiment was made with more different granular materials:
  - Barley
  - Polenta
  - Plastic pellets
  - Wooden pellets

Data used in computer analysis

1. Plastic pellets

Cont.

2. Polenta

Data analysis

- We analyzed three parameters :
  - Marginal angle of slipping(video)
  - Angle when avalanche stops(video)
  - Size of avalanche (aproximation from audio)

Data analysis results

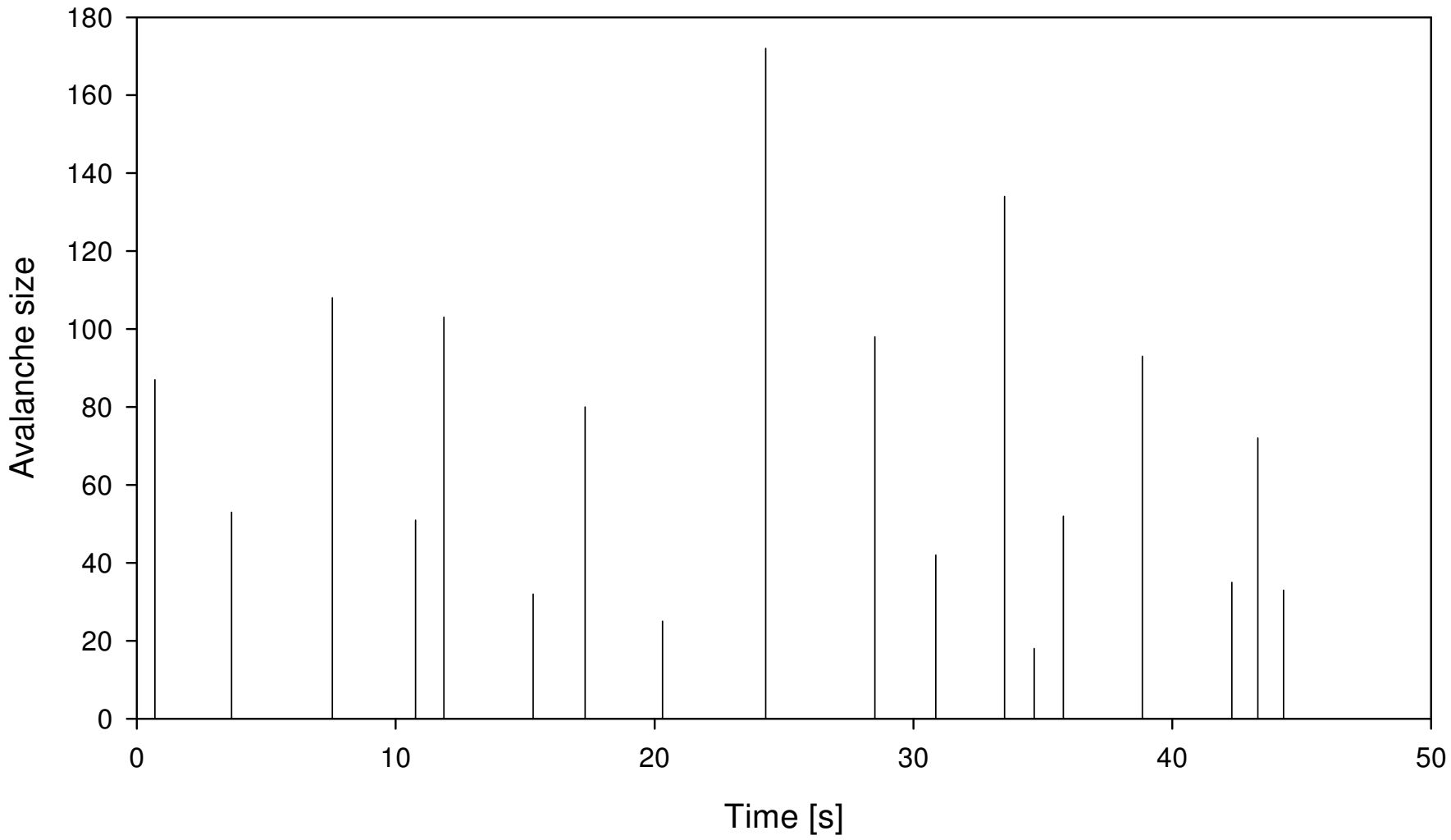
Graular	Slipping angle(average)	Stopping angle(average)
Polenta	45,9°	38,7°
Plastic pellets	42,4°	36,3°
Barley	40,6°	39,4°
Wooden pellets	49,5°	31,5°

Experimental data conclusions

- Eliptic particles slip on much smaller angle than spherical particles but they stop on much bigger angle

- Particles that have higher density have bigger slip angle because they press each other harder so friction is bigger

Data analysis results cont.

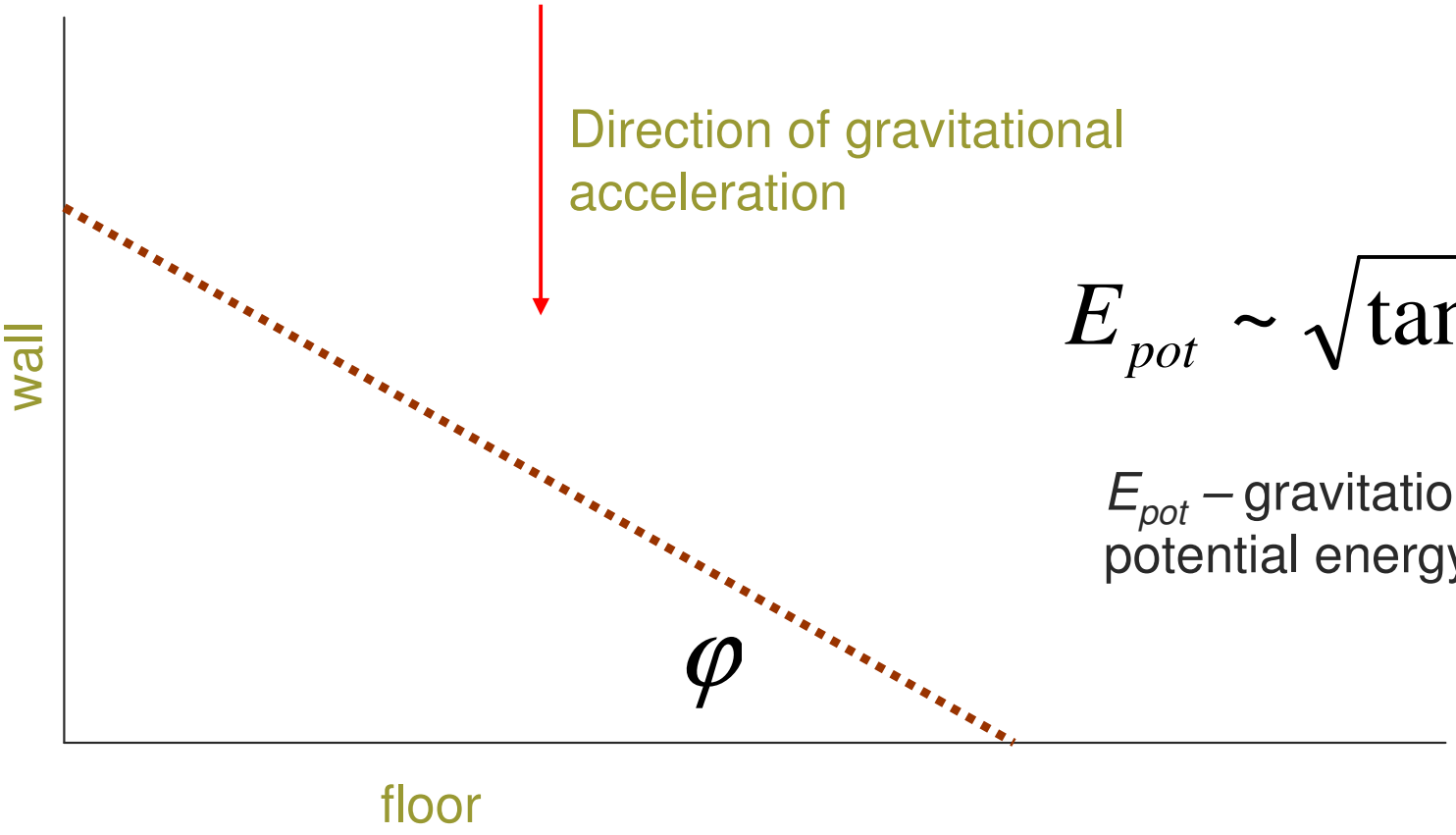


Explanation

- Avalanche – due to energy changes
- Two counteracting effects: potential energy decrease and friction
- The stopping of the avalanche – dictated by entropy conditions
- The theory is qualitiative!

Explanation cont.

- System considered: granular slope
- The system tends to minimize its potential energy

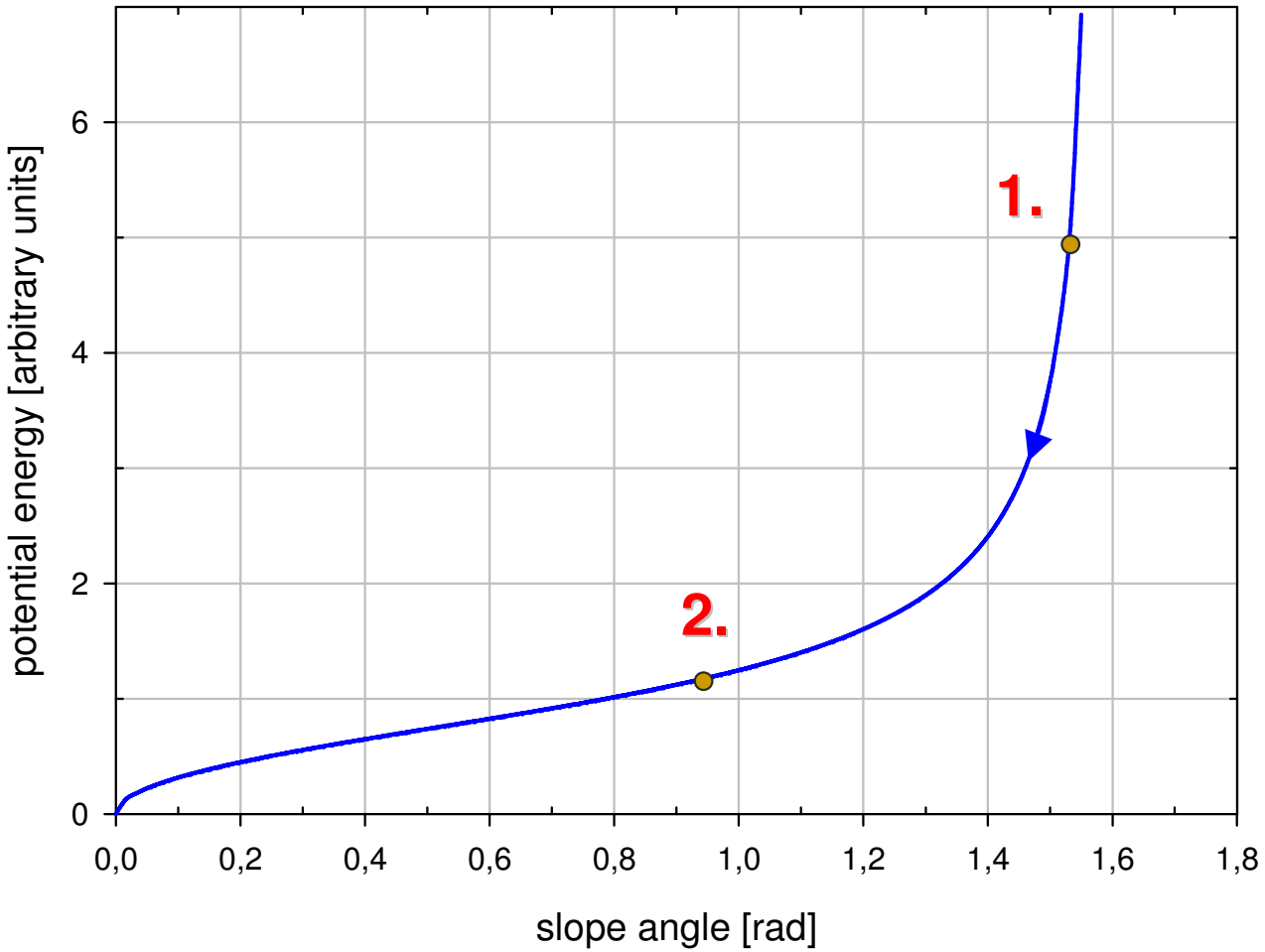


$$E_{pot} \sim \sqrt{\tan \varphi}$$

E_{pot} – gravitational potential energy

Explanation cont.

- Potential curve:



1. – initial state
2. - final state (spontaneous transition)

The final angle is not 0 due to friction!

Explanation cont.

- Entropy condition for spontaneous transitions:

$$\Delta S > 0$$

ΔS – net entropy change

- Minimalizing potential energy: entropy gets smaller!
- Friction – increases entropy

$$\Rightarrow -\Delta S_{pot} + \Delta S_{fr} > 0$$

ΔS_{pot} – entropy change due to potential energy

ΔS_{fr} – entropy change due to friction

Conclusions

- Critical angle and stopping angle depends on:
  - particle shape
  - particle density
  - friction between particles

Conclusions cont.

- Cause of starting: minimalising energy
- Cause of stoping: friction between particles