# 17th IYPT
# AUSTRALIA - Brisbane
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# Problem 10 – Two Chimneys

- *"Two chimneys stand on a box with one transparent side. Under each chimney there is a candle. A short period after the candles are lit one flame becomes unstable. Examine the case and present your own theory of what is happening."*

# Introduction - Aplication

- Factories:

# Theoreticals bases

- **Perfect gases**
- Clapeyron' s equation:

  P.V=n.R.T

  R = 0,082 atm.L/mol.K or 62,36 mmHg.L/K.mol;
- Van der Waals:
- The ideal gas equation of state is only approximately correct. Real gases do not behave exactly as predicted. Thus, modifications of the ideal gas law, PV = RT, were proposed.
- Van der Waals equation: $\mathbf{(P + a/V^2)\,(V - b) = RT}$

# Convection

- Convection is the motion of fluids due to the difference of the density that switch their position because the temperature's difference among them.
- The convection can be natural or forced.

# Methodology

- Experiment:
- Changes in the parameters
- Experiment + Theory
  - Convection
  - Gas law
  - Chimney effect

Conclusion

# Experience - Materials:

- Box
- Paper
- Two candles
- Transparent plastic
- Plastic
- Cilindrical tubes
- Fire-lighter
- Aluminium paper

# Experience - Proceeding

- Box with chimneys and candles;
- Smoke to see the phenomenon occurring;
- One of the candles became unstable;
- Influence of the parameters.

# The possible parameters

- Chimneys' height
- Chimneys' thickness
- Candles' height
- Candles' constitution (density, paraffin, wick's pureness)
- Box's volume
- Ambient temperature

vídeo

- Box:
- 27.0cm x 18.0cm x 9.5cm = $4.6x10^3cm^3$
- Cilindrical chimneys:
- Diameter: 5.0cm
- Height: 14.0cm
- Candles:
- Height: 11.0cm

# Experimental data I

Box: 27.0cm x 18.0cm x 9.5cm =
= $4.6 \times 10^3 cm^3$
Chimneys'diameter =
= 5.0cm
Height of the candles =
=11.0cm

| Chimneys' height | Phenomenon observed |
|---|---|
| 10 cm | None of the two candles became unstable |
| 14 cm | One of the candles became unstable |
| 18 cm | One of the candles became unstable |
| 20 cm | One of the candles became unstable |
| 25 cm | One of the candles became unstable |

# Experimental data II

- Box:
- 10.0cm x 25.0cm x 7.5cm =

= $1.9 \times 10^3 cm^3$

- Cilindrical chimneys:
- Diameter: 5.0cm
- Height: 8.5cm
- Candles:
- Height: 6.0cm

With this chimneys, we can't observe the phenomenon. But increasing one of the chimneys the flame of the candle under the shorter chimney became unstable.

# Experimental data III

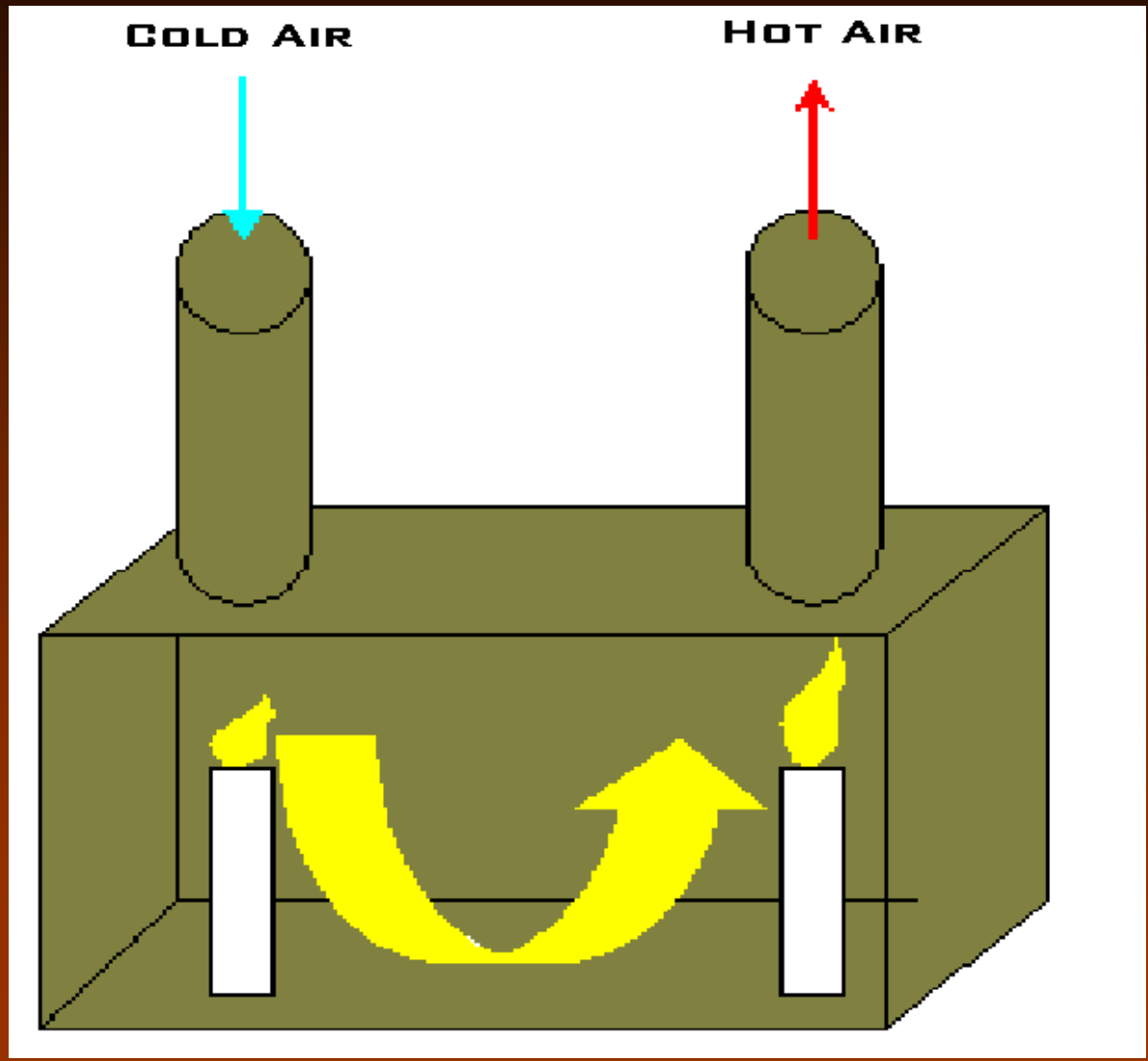
Box: 27cm x 18cm x 9.5cm =
= $4.6 \times 10^3 cm^3$
Chimneys'diameter =
= 5cm
Chimneys' height =
= 20 cm
Height of the candle 1 =
= 11 cm

| Height of the candle 2 | Phenomenon observed |
|---|---|
| 6 cm | None of the two candles became unstable |
| 7 cm | None of the two candles became unstable |
| 8 cm | The flame of the higher candle became unstable |
| 9 cm | The flame of the higher candle became unstable |
| 10 cm | The flame of the higher candle became unstable |

# Conclusions I

- The combustion of the paraffin that occurs inside the box, due to the candles, release a lot of heat, heating up the inner air. This last one become less dense and come up, going out of the chimneys. Because of it, the box´s inner pressure reduce, and the external air (colder than the inner air) go inside the box passing through one of the chimneys.
- The air begin to left the box for one chimney and enter in the box for the other because of little differences between the candles.

# The air´s convection



# Conclusions II

Box´s volume:

- => small boxes – Less time to start the process
- => big boxes – More time to start the process

Height of the chimneys:

- => high chimneys – The flow increased
- => low chimneys – The flow reduced

Thickness of the chimneys:

- => thick chimneys – The flow increased
- => thin chimneys – The flow reduced
- The bigger the difference of temperature (between inside and out of the box), the bigger the flow. So the candles´ quality and the ambient temperature are also important.