BRAZILIAN TEAM

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

14. Fountain

Construct a fountain with 1m ‘head of water’. Optimise the other parameters of the fountain to gain the maximumjet height by varying the parameters of the tube and by using different water solutions.

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Introduction

I. Applications of the study

Irrigation

Fuel injection

Methodology

I. **Bibliographic research**

II. **Theory and experiment for maximum jet height**

III. **Determination of the Relevant Parameters**

IV. **Maximization of the jet height**

General View

I. Tank -> Mariotte siphon

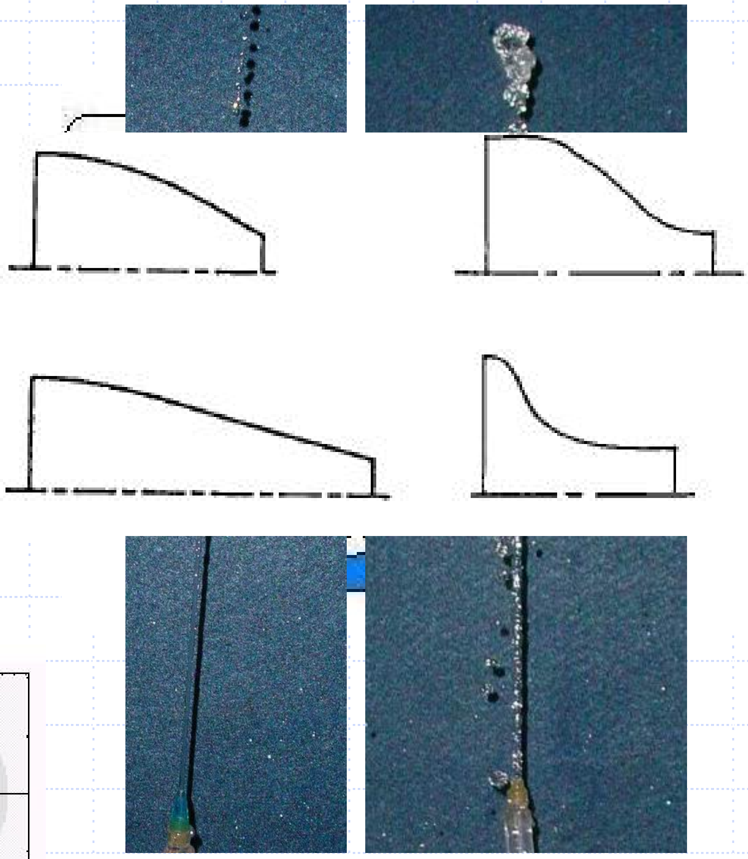
II. Tube -> Wide diameter

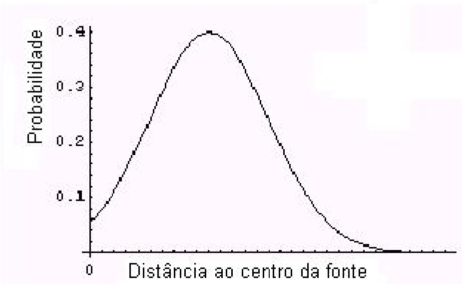
III. Nozzle -> Smooth

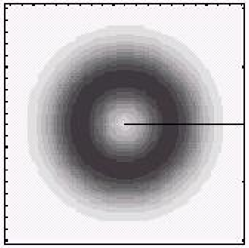
IV. Jet

a) Thin

b) Thick

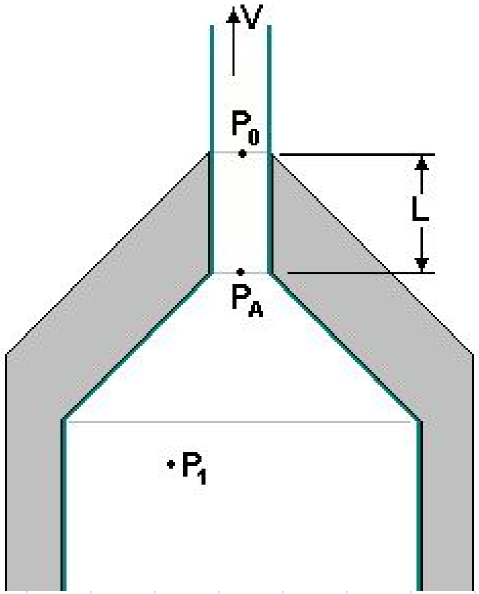






Mathematical Analysis

I. Jet escape speed on the nozzle



From Bernoulli Eq.

$$P_1 = P_A + \frac{1}{2}\rho V^2$$

Hidrostatics

$$P_1 - P_0 = \rho g Y$$

a) Laminar flow

Poisseuille Law

$$Q = VS = \frac{\pi r^4 \Delta P}{8\eta L}$$

$$V = \sqrt{2gY + b^2} - b$$

Where $b = \dfrac{8\eta L}{r^2 \rho}$

b) Turbulent flow

$$\frac{(P_A - P_0)r}{L\rho V^2} = 0.079\ \mathrm{Re}^{-0.25}$$

From Prandtl one-seventh power law

Turbulence discussion

$$\mathrm{Re} = \frac{d\rho V}{\eta}$$

Mathematical Analysis

II. Jet height dependence

$$\rho = \frac{3m}{4\pi R^3} \qquad V_0 = \sqrt{V^2 - 2gh_0}$$

From Stokes Law: $\vec{F} = -6\pi\eta R\vec{v}$

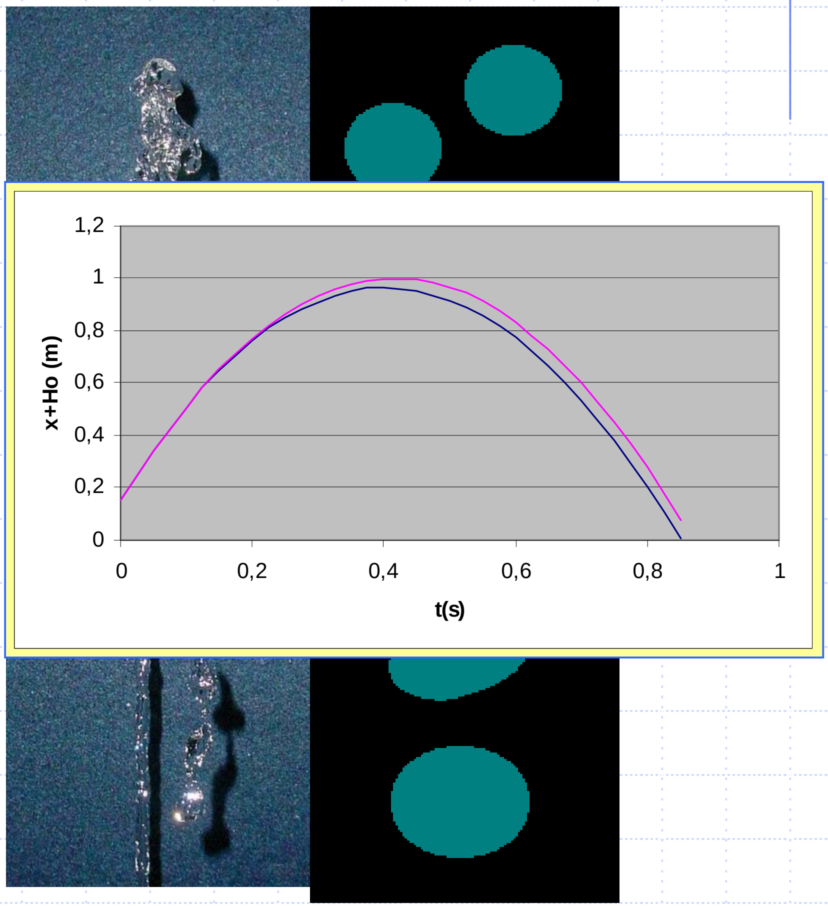
Motion: $$m\frac{d^2x}{dt^2} = -mg - 6\pi\eta_{ar} R\frac{dx}{dt}$$

Solving:

$$x(t) = \frac{(g + aV_0)(1 - e^{-at}) - gat}{a^2}$$

Where $a = \dfrac{9\eta_{ar}}{2R^2\rho}$

Finally $$H = \frac{1}{a}\left[V_0 - \frac{g}{a}\ln\left(1 + \frac{aV_0}{g}\right)\right] + H_0$$



→ Other influences on jet height

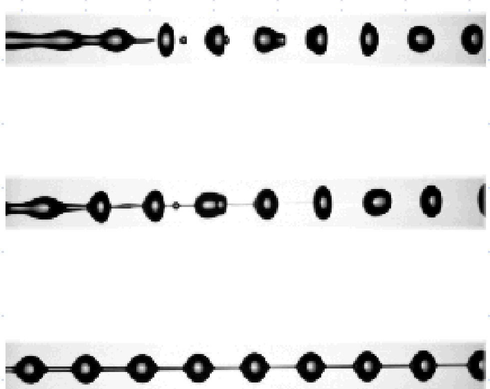
Water Solutions

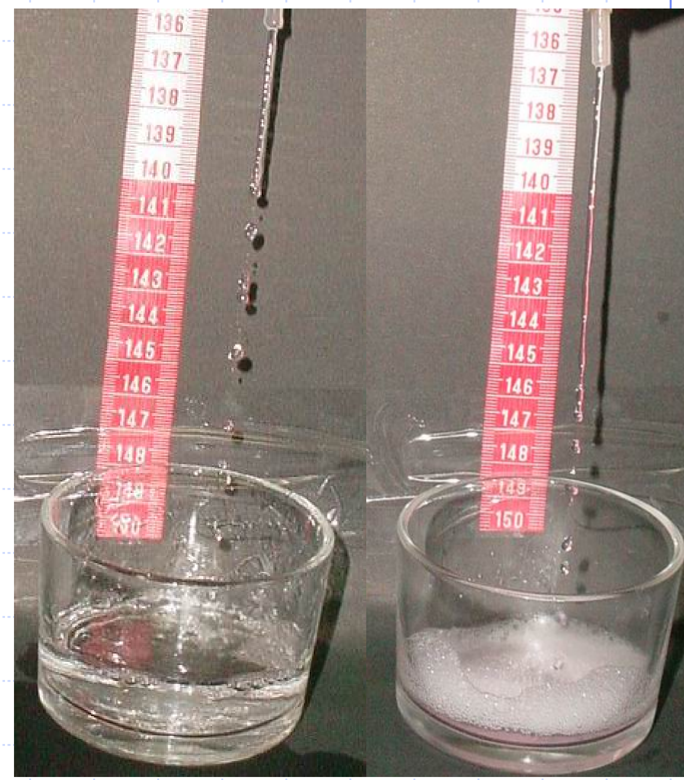
I. Density

II. Viscosity

III. Surface tension (temperature)

IV. Viscoelastic solutions (polimers)





Experiment

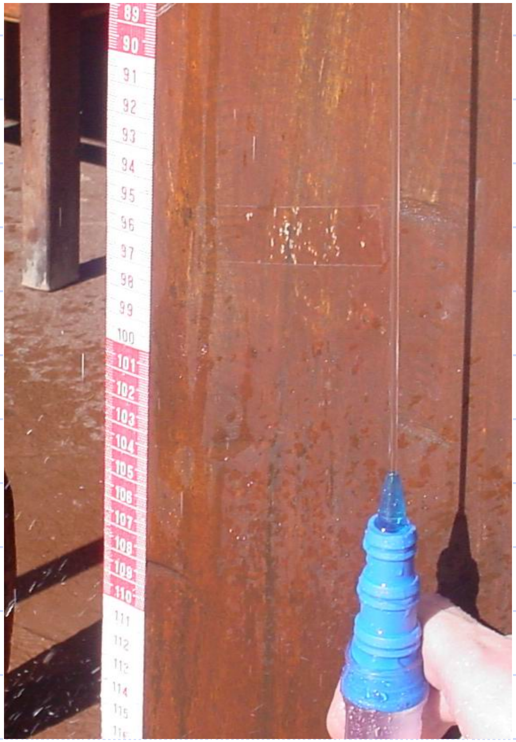
General Schematic

Calibration of the Mariotte Siphon

Detail of the Mariotte Siphon

Experiment

Practical measure



Jet escape

Jet top detail

Nozzle detail

Experimental Data

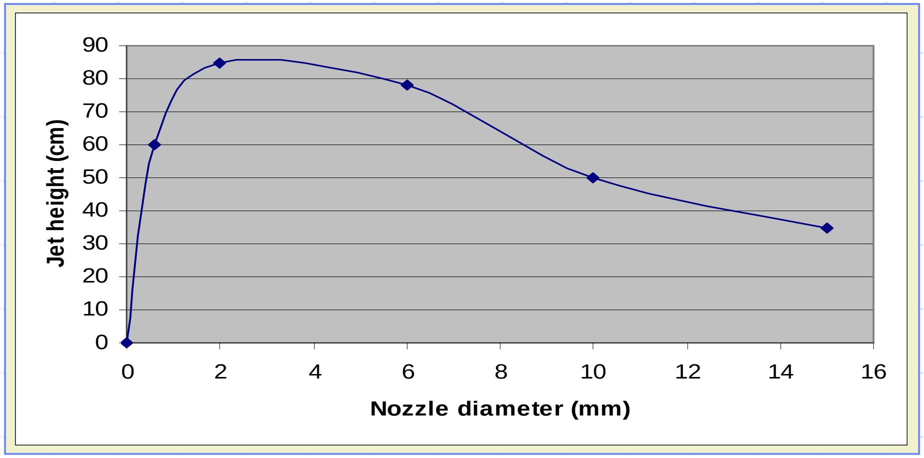
Water at temperature (°C)	Average jet height (cm)
25	85
50	84
75	81

I. Theory validity

II. Proposition of the optimal parameters

Solutions	Average jet height (cm) at 25°C
Detergent solution (about 0.2g/L)	83
Detergent solution (about 1g/L)	82
Salt solution (density about 1.2g/cm^3)	85
Salt solution (density about 1.5g/cm^3)	86

Tube diameter (mm)	Average jet height (cm) at 25°C
0	0
0,6	60
2	85
6	78
10	50
15	35



Source of Errors

- Loss of energy
- Imprecision on the measure
- Air resistance