University of Abdelhafidh Boussouf Mila
Fluid Mechanics PW

2nd Year Process Engineering
March 2026

WP01 : Falling-Ball Viscometer

1. Objective :

The objective of this practical work is to implement a classic method for measuring the viscosity of a liquid using a falling-ball viscometer.

2. Theoretical Study

Consider a sphere (ball) of radius r released into a viscous fluid. The ball is subjected to three primary forces: its weight P, the buoyancy force F_A (Archimedes' principle), and the drag force (friction) F_f exerted by the fluid on the ball. The latter is defined by Stokes' Law.

Using a downward-oriented vertical axis Oz, these forces are expressed as follows:

- Weight of the ball (w): $w = m_{ball} \times g = \rho_{ball} \times V_{ball} \times g$
  - *mball : mass of the ball.*
  - *ρball : density of the ball.*
  - *Vball : volume of the ball.*
  - *g : acceleration due to gravity.*
- Buoyancy Force: $F_A = \rho_{fluid} \times V_{ball} \times g$
  - ρ_{fluid}: Density of fluid.
- Buoyancy Force: $F_f = 6\pi \times r \times \mu \times v$
  - *r :* radius of the ball.
  - μ: dynamic viscosity of the fluid.
  - v : terminal velocity of the ball falling through the fluid.

Ce qui nous permet d'établir l'expression de la viscosité dynamique du fluide :

$$\mu = \frac{2}{9}\frac{g.r^2}{v_{lim}}\left(\rho_{ball} - \rho_{fluid}\right) \qquad (*)$$

3. Données

Glycerin Density	Ball Density	Theoretical Viscosity of Glycerin (at 20°C)
1,25	**7,8**	**1,49** *Pa.s*

- ✓ **4. Experimental Procedure**
- ✓ A ball is dropped into a viscous fluid (glycerin) contained within a graduated cylinder. The cylinder radius (R) is significantly larger than the ball radius (r), such that R≫r.
- ✓ Release the ball with zero initial velocity into the glycerin.
- ✓ It is assumed that between markers A and B, the ball reaches terminal velocity; the motion is therefore rectilinear and uniform.
- ✓ Under these conditions, the sum of external forces is zero: $\sum F = 0$.
- ✓ Measure the terminal velocity by determining the time taken to travel the distance between two distant graduations (AB) using a stopwatch.

First and Last Name

1 ……………………………………………

2……………………………………………

3……………………………………………

4………………………………………………

1. Determination of the Dynamic Viscosity of Glycerin

- Temperature (T) ***T* = ………. °*C***
- Ball Diameter (D): ***D* = ……………… *mm***
- Distance (AB): ***AB* = ………………………*mm***

Trial	t (s)	v (m/s)	μ (Pa s)	μ_{moy}
1				
2				
3				
4				
5				
6				
7				

Comparison between experimental and theoretical values	
Formula	**Value**
$\varepsilon\,\% = \frac{\Delta\mu}{\mu}$ x100 = …………………………………	……………………………………

- **2. Effect of the ball radius**

Complete the following table: for distance AB*:* ………………………

Ball Diameter (mm)	Time (s)	Velocity (m/s)	*μ (Pa s)*	μ_{moy}
D_1 = 3,175 mm				
D_2 = 2,381 mm				
D_3 = 1,588 mm				

2.2. Plot the viscosity curve as a function of ball diameter (Fig. 1)

Effect of fluid nature

Fluide 1 : …………………

- Temperature: ……………
- Mass : ………………..
- Volume : ……………..
- Density : ……………….

Fluide 2 : …………………

- Temperature: ……………
- Mass: ………………..
- Density: …………………..
- Density: …………………..

3.1. Complete the following table,

- Ball Diameter ***D* = ……………… *mm***
- Distance ***AB* : ………………………*cm***

Fluids	Time (s)	Velocity	μ *(Pa s)*	μ_{moy}
Glycerin				
water				
1.……………….				
2.…………..……				

3.2. Plot a grouped histogram to compare the viscosities of different fluids.

Conclusion (Comment on and interpret your results)

……

……

……

……

……

……

……

……