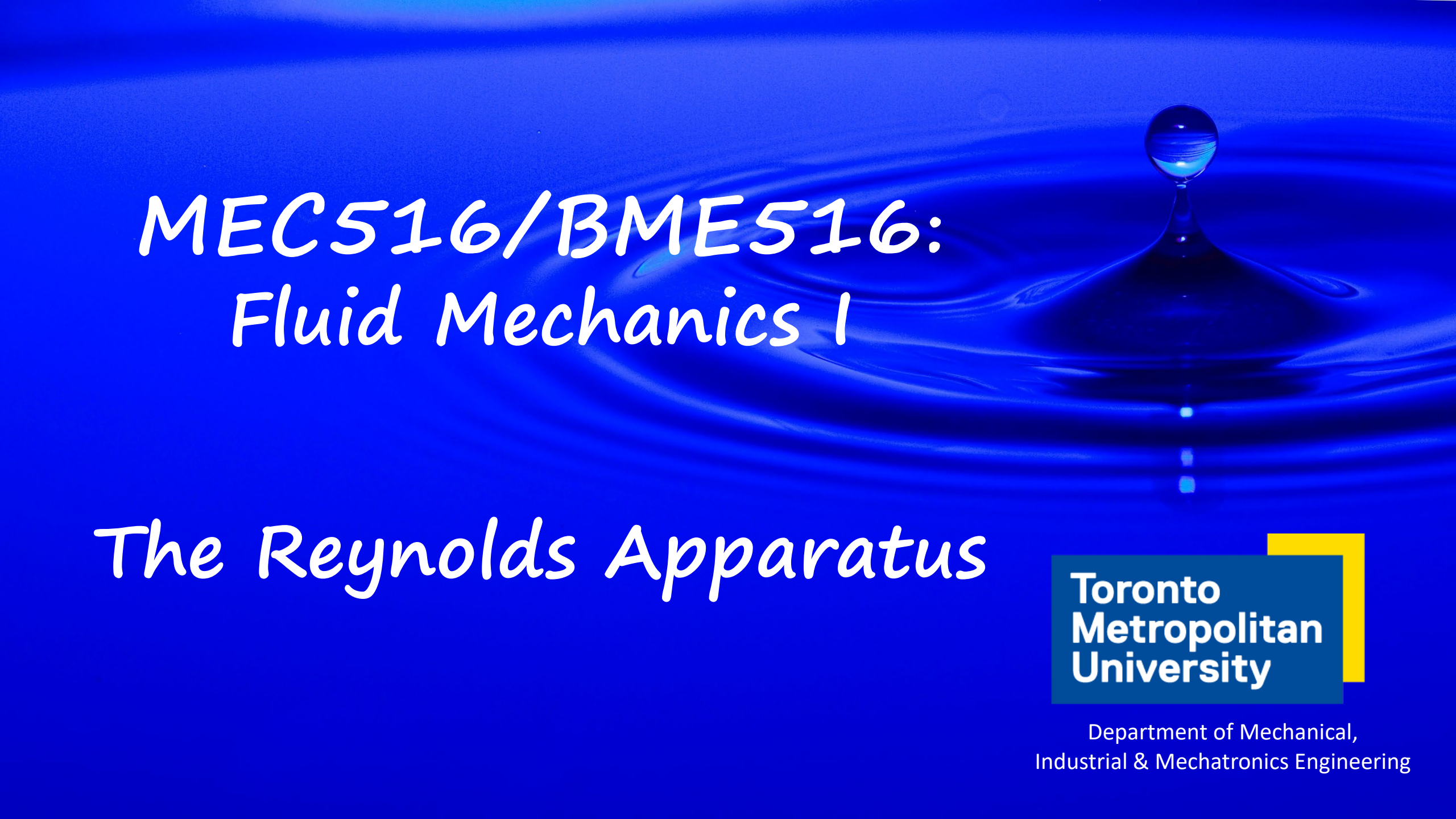


MEC516/BME516: Fluid Mechanics I

The Reynolds Apparatus

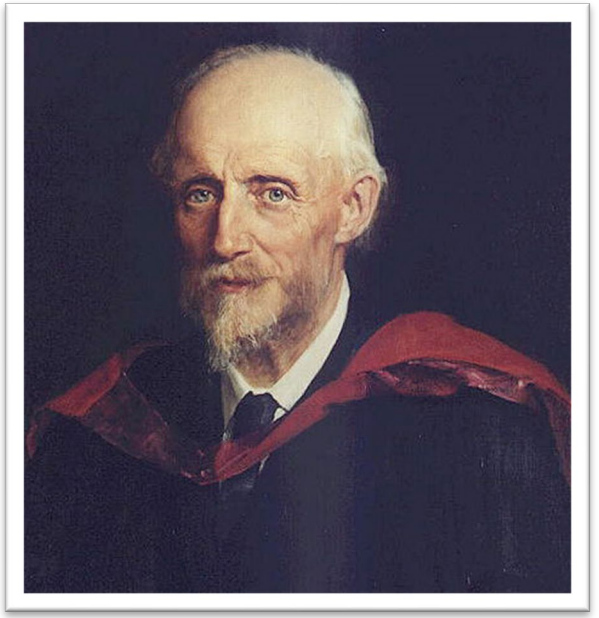
Toronto Metropolitan University

Department of Mechanical, Industrial & Mechatronics Engineering

Reynolds Number (Re)

- For a pipe flow:

$$Re = \frac{\rho \bar{V} D}{\mu}$$



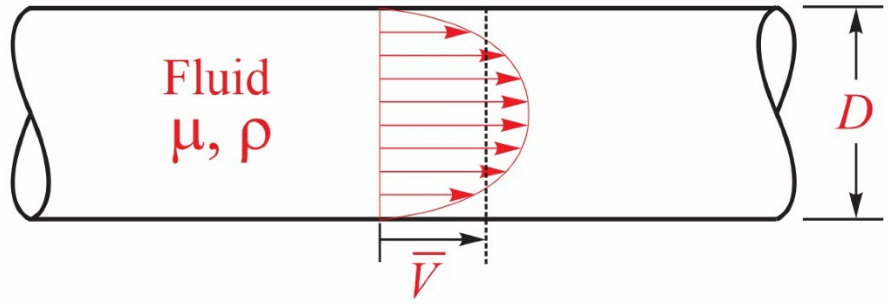
Osborne Reynolds: Irish pioneer in fluid dynamics

ρ *fluid density*

$\bar{V}$ *fluid average velocity*

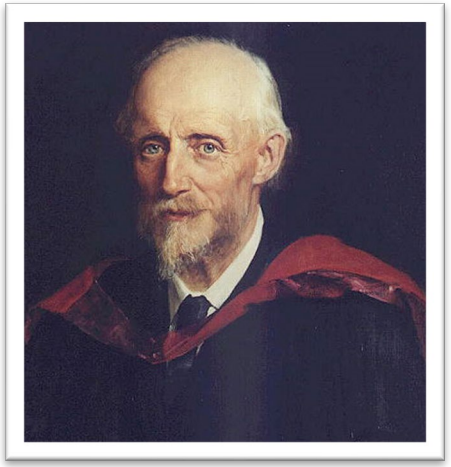
D *inside pipe diameter*

μ *fluid dynamic viscosity*



- Reynolds showed (1883) that this dimensionless parameter determines the character of a flow

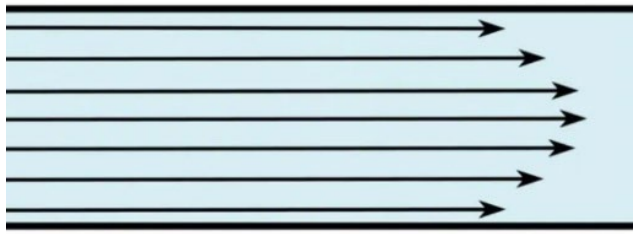
Reynolds Number (Re)



- Reynolds showed (1883) that this dimensionless parameter determines the character of a flow

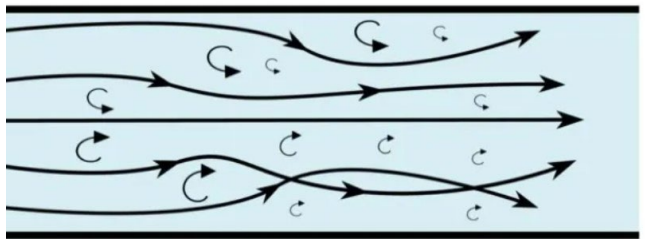
$$Re = \frac{\rho \bar{v} D}{\mu}$$

Low Re



Laminar Flow (smooth steady flow, layer over layer)

High Re



Turbulent Flow (unsteady eddies or vortices, mixing)

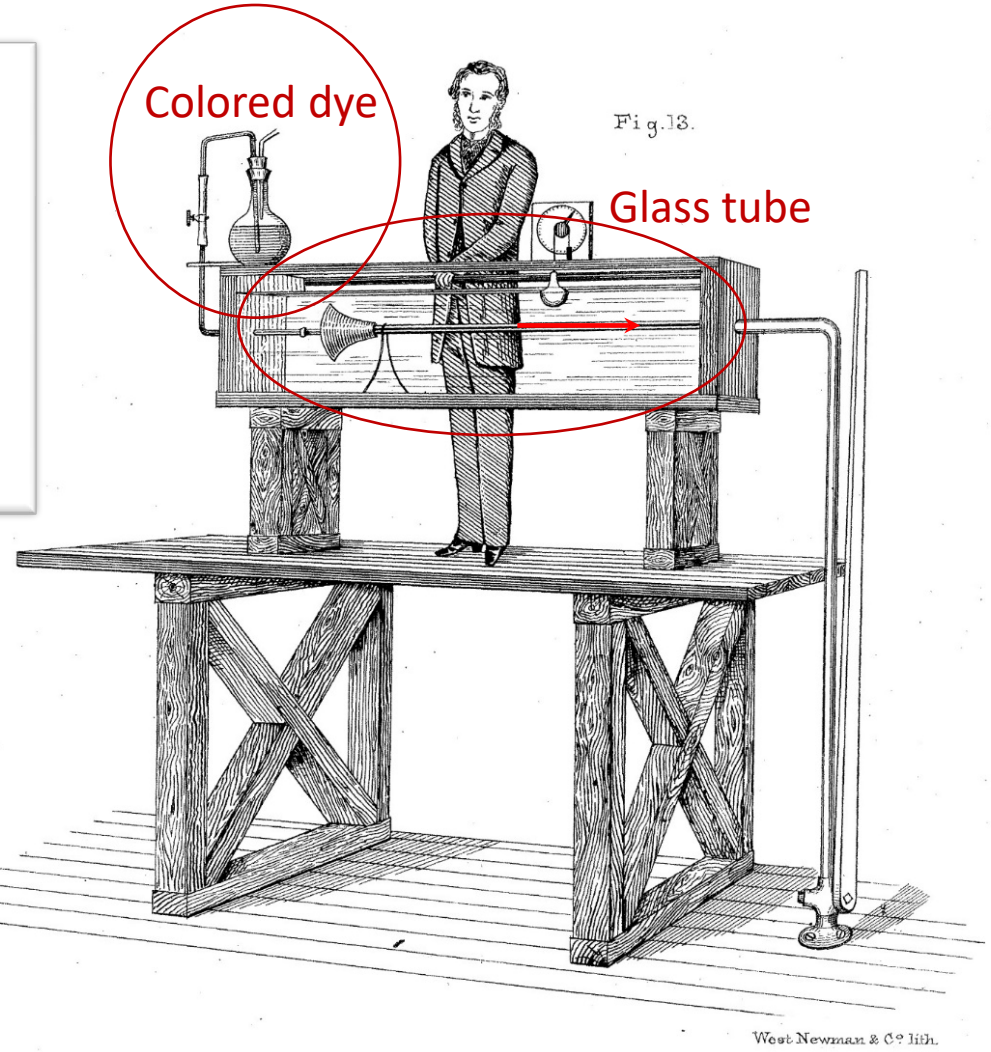
The Reynolds Apparatus (1883)

Philosophical Transactions of the Royal Society of London, Vol. 174 (1883), pp. 935-982

XXIX. *An Experimental Investigation of the Circumstances which determine whether the Motion of Water shall be Direct or Sinuous, and of the Law of Resistance in Parallel Channels.*

By Osborne Reynolds, *F.R.S.*

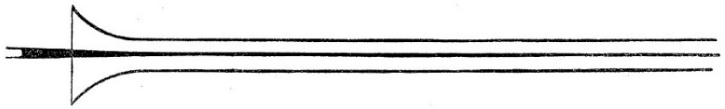
Received and Read March 15, 1883.



- Colored dye injection to visualize the flow of water
- Hand sketches with 3 different diameter glass tubes

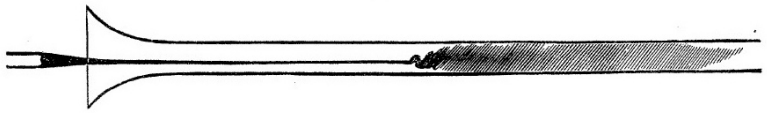
Laminar flow
(Low Re)

Fig. 3.

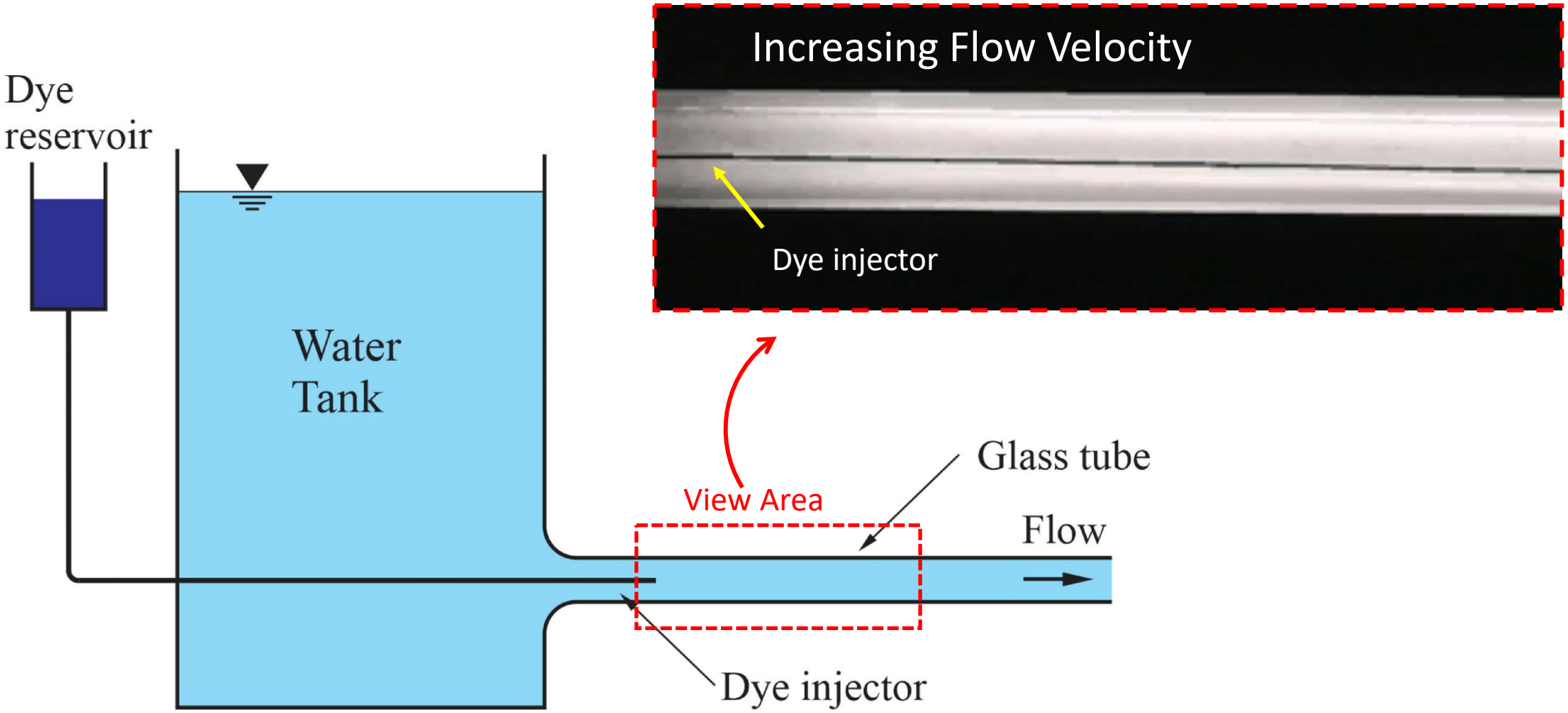


Turbulent flow
(High Re)

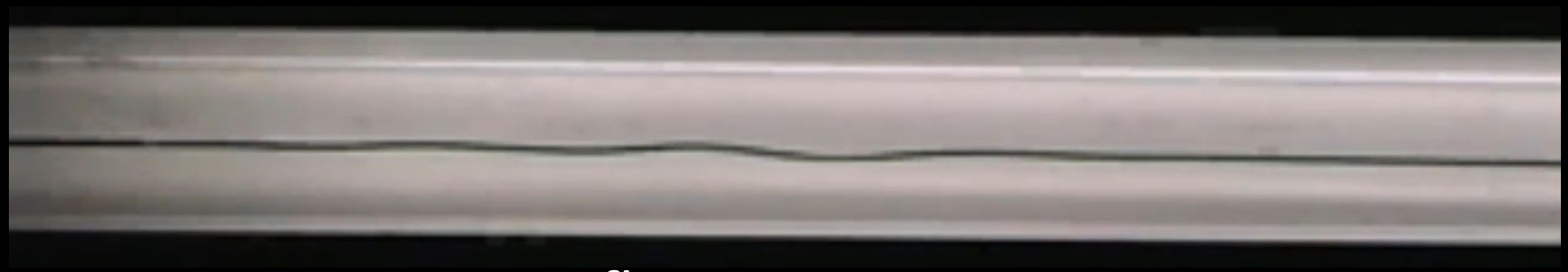
Fig. 4.



The Modern Reynolds Apparatus (Lab 2)



“Rules of Thumb” for Engineering Design Purposes



Laminar flow Re < 2300

Transitional flow 2300 < Re < 4000

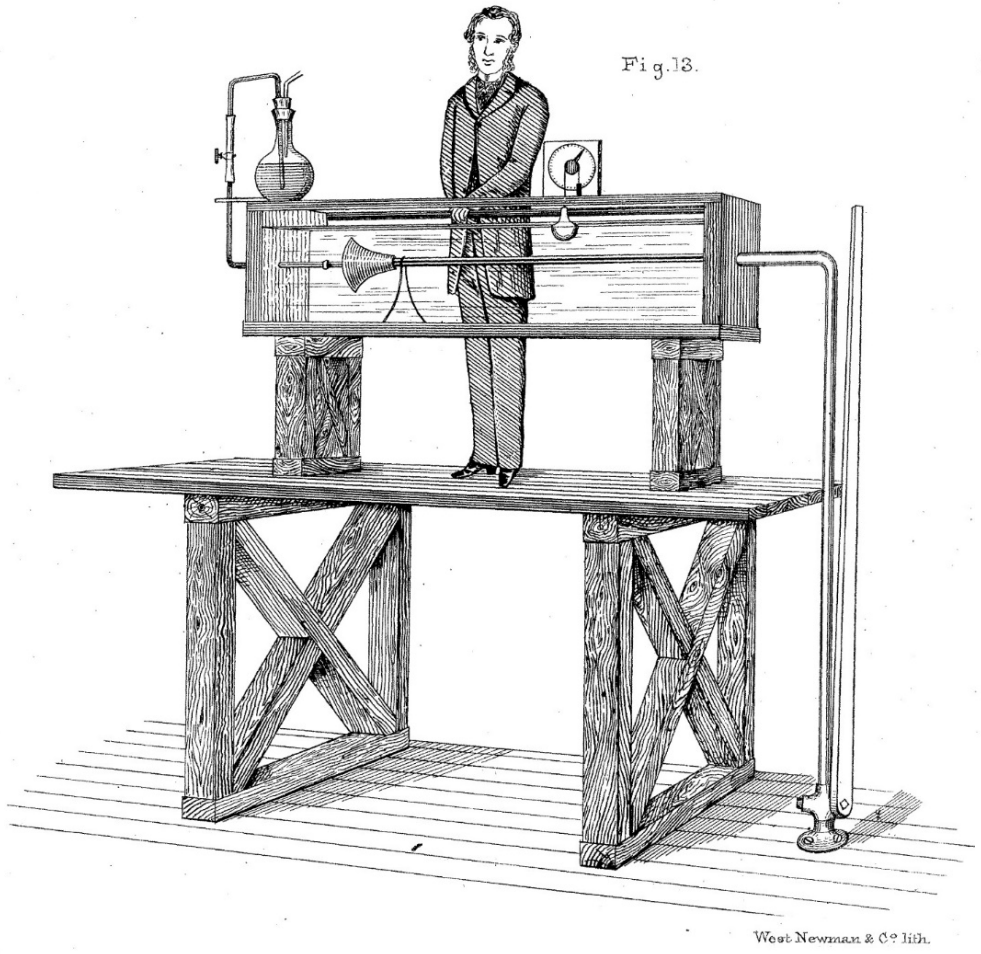
Fully turbulent flow Re> 4000

“Rules of Thumb” for Engineering Design Purposes

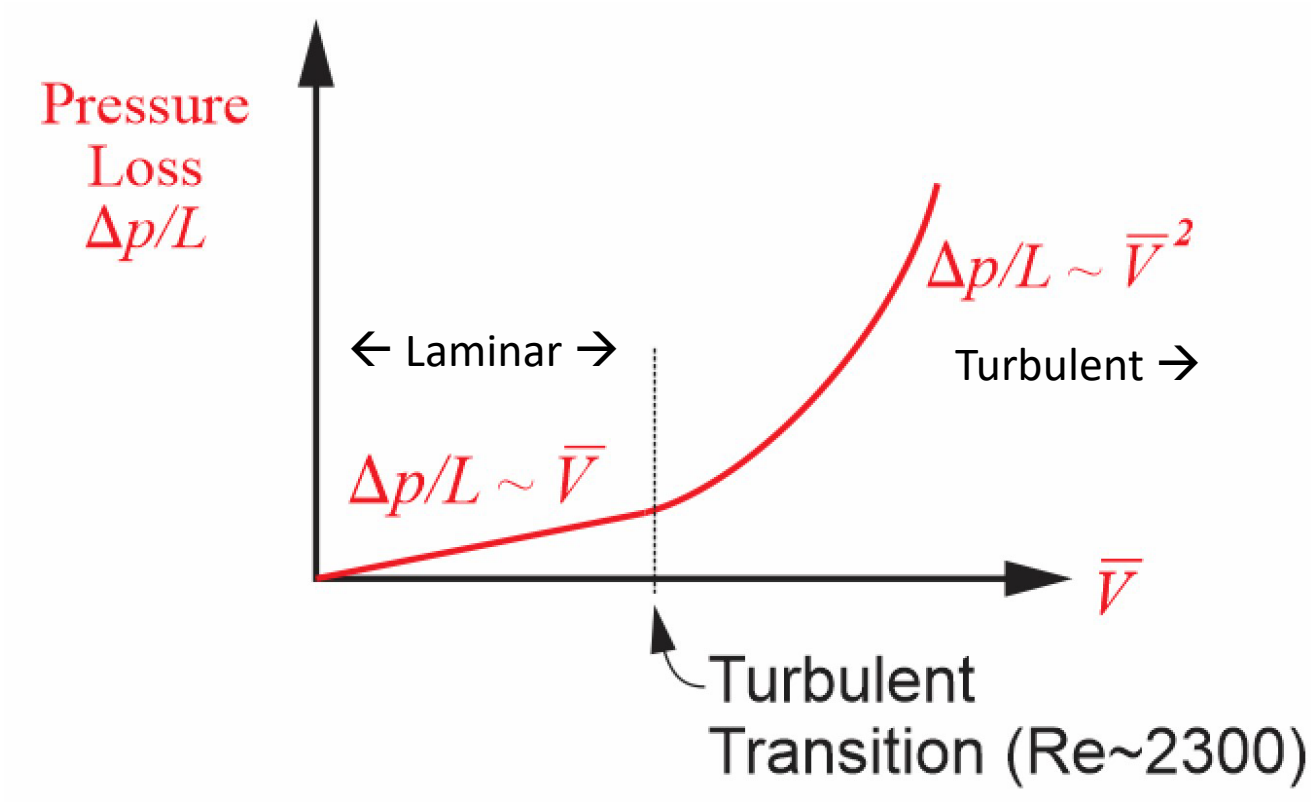
- Results are for a **smooth** pipe

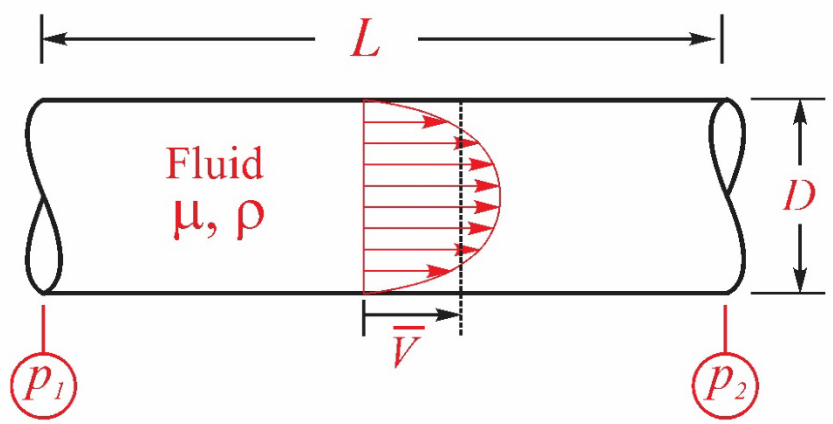
- Transition is highly dependent upon:
  - Pipe roughness e.g., Transition will occur at lower Re for a rough cast iron pipe
  - Inlet flow disturbances

- Reynolds was able to get **laminar** flow for Re=14,000!

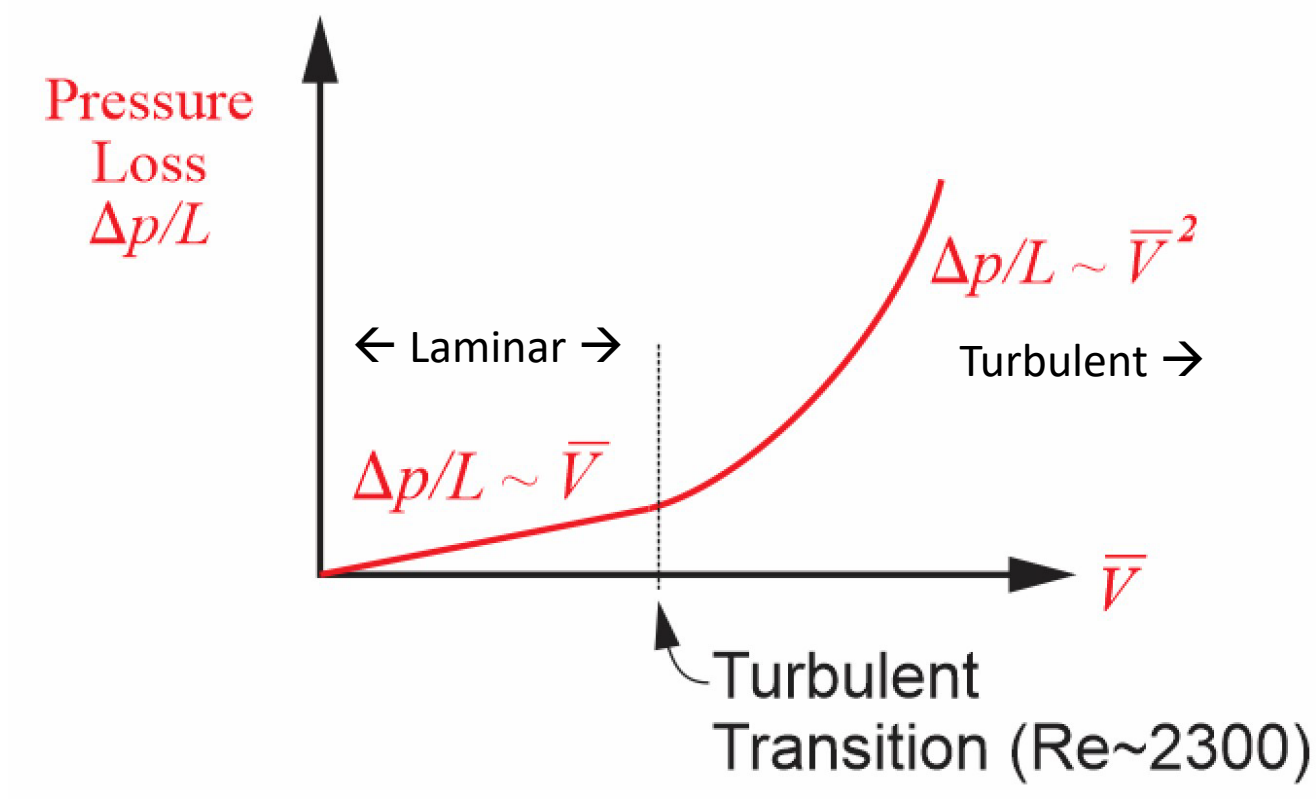


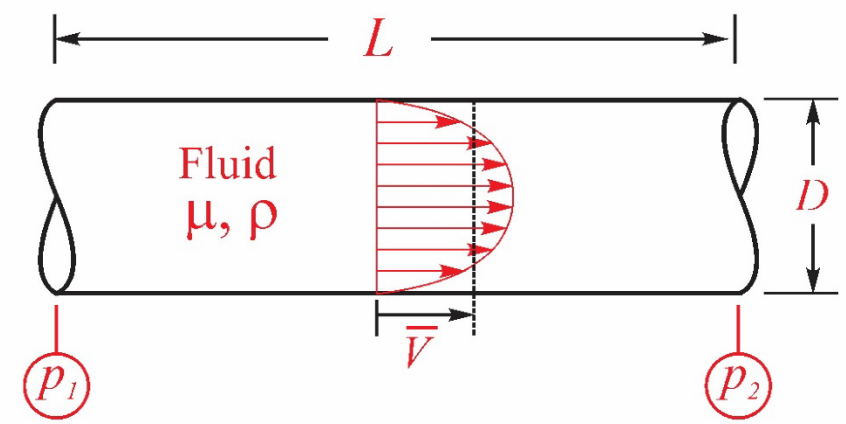
Importance for Design of Piping Systems





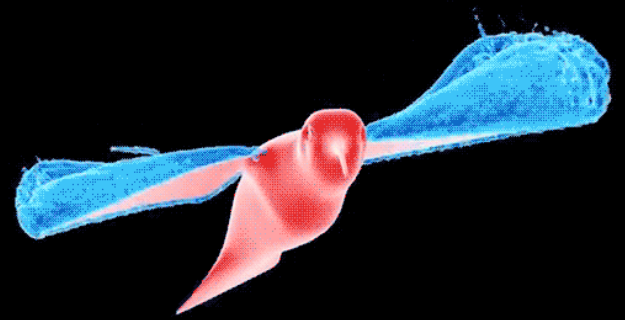
Importance for Design of Piping Systems





- Laminar flow: 2X flow rate → 2X pumping power
- Turbulent flow: 2X flow rate → 4X pumping power

Most Real-World Flows are Turbulent



Animation Credits: giffy.com

End Notes

- Presentation by Dr. David Naylor, 2023

Toronto Metropolitan University