

Intro to Real Internal Flows

Real Internal Flows – Lesson 1



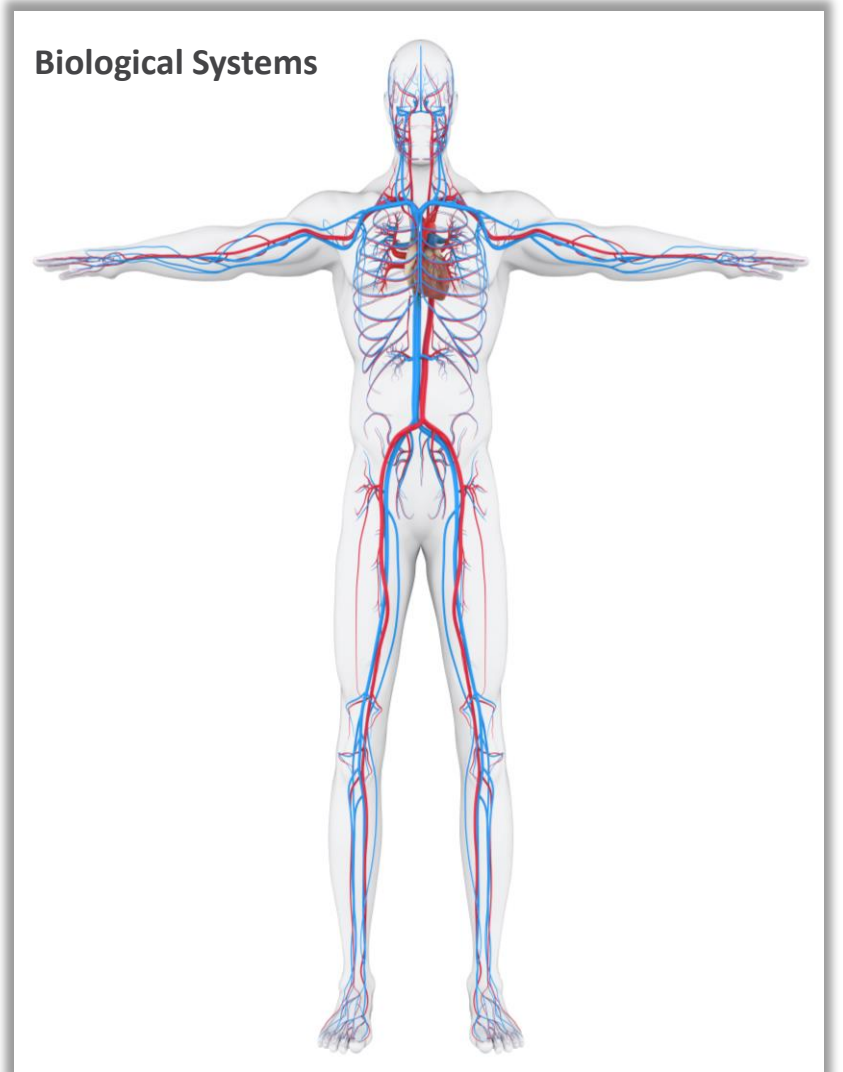
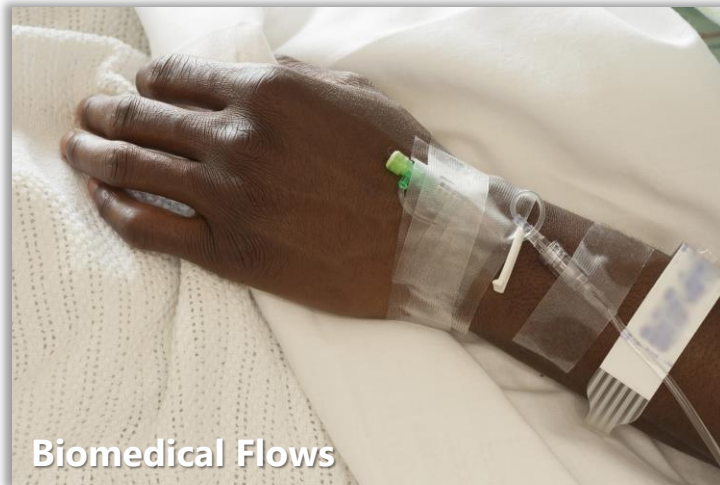
/ Intro

- In this course, we will concern ourselves with realistic internal fluid flows across all fluid regimes from laminar to turbulent.
- Internal flows differ from external flows in that the flow is confined by one or more solid walls.
- Constraining the flow in this way has many implications for the behavior of the velocity and the subsequent losses due to viscous effects.



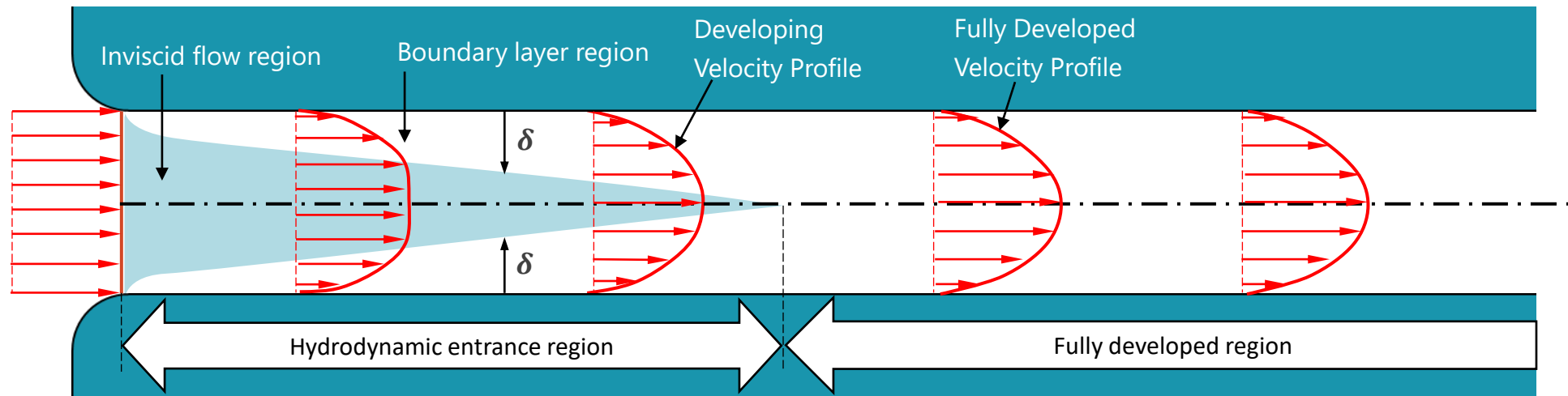
- Applications of internal flow analysis are numerous – pipes, ducts – literally any confined space!

Examples of Internal Flows



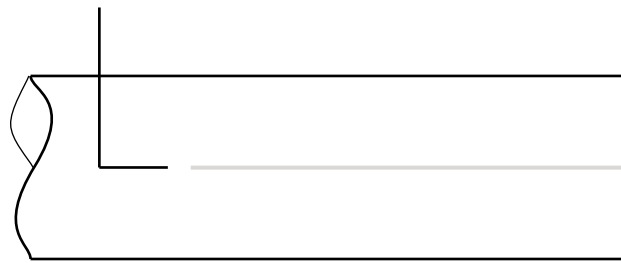
Internal Flow – Basic Flow Features

- Let's look at a simple pipe or duct flow as shown in the figure below.
- The flow field can be divided into two basic regions:
 1. Entrance Region – Boundary layer forms and begins to grow on the walls.
 2. Fully-Developed Region – Boundary layers merge and the viscous effects are seen across the pipe.
- As we will see, the nature of the velocity and pressure fields changes as the flow becomes fully-developed.



/ Laminar Versus Turbulent Flow

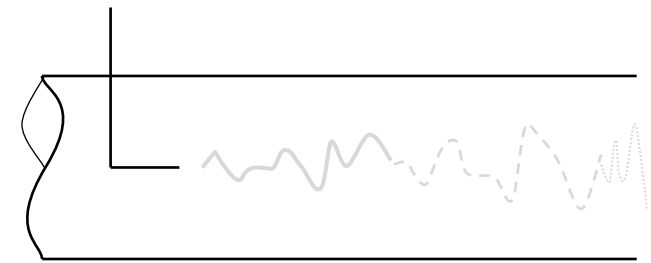
- Internal flows can be either laminar or turbulent with a transition zone between the regimes.
- Osborne Reynolds' dye trace experiment in the late 19th century demonstrates the classification of the flow, as illustrated below.
- Most practical internal flows are turbulent.



Laminar



Transitional



Turbulent

/ The Reynolds Number for Internal Flow

- Laminar flow illustrates that little or no mixing of the dye occurs, and the dye streak follows a distinct streamline. The fluid planes appear to slip over one another.
- Turbulent flow exhibits mixing and disperses the dye due to fluctuating (random) velocity components.
- In a smooth pipe of circular cross section, the transition from laminar to turbulent flow occurs at a Reynolds number of around 2300.
- In internal flow analysis, the Reynolds number is normally based on the hydraulic diameter D_h of the internal passage:

$$Re_{D_h} = \frac{\rho V_{\infty} D_h}{\mu}$$

$$D_h = \frac{4 \times \text{area}}{\text{wetted perimeter}} = \frac{4A}{P}$$

- In this course, we will omit subscript D_h and will be denoting the Reynolds number simply as Re .

/ Flow Geometries

- Internal flow geometries can range from simple to complex
 - Straight pipe or duct
 - Pipes and ducts with simple bends
 - Complex internal passages with obstructions and restrictions
 - Manifolds
 - Complex internal flow network (parallel-serial passages, obstructions, etc.)



Basic piping components



Jet engine piping system

/ Internal Flow — What Do We Want to Know?

- Internal flows are seen anywhere a fluid is transported from one point to another.
 - Example – water is pumped from a municipal water source to your home
- As the flow travels through the internal passages, energy is lost due to viscous effects and turbulence. As the loss increases, more power is required to pump the fluid at a given flowrate.
- Therefore, for internal flow analysis, we wish to know **how much loss an internal passage will develop**, so we can size the pumping system accordingly.
- In the lessons which follow, we look at a range of internal flow analyses and show how losses can be estimated for range of common configurations.

/ Summary

- The subject of internal viscous flows is very important because internal flows are present in many industrial and consumer applications ranging from chemical processing to household appliances.
- Internal flows can be laminar, transitional or turbulent based on the Reynolds number, but most practical internal flows are turbulent.
- In the next lessons we will take a closer look at fully developed internal turbulent flows.

 **Ansys**

