Task 02: Hemodynamic Risk Assessment in Stenotic Arteries

Software: ANSYS Student (Fluent)

Due Date: Thursday 11th Dec .2025

Group Task (4-5 members)

The Problem Statement

In clinical settings, Physicians often use simplified mathematical formulas (like Bernoulli's Equation) to estimate pressure drops across heart valves or arterial blockages. However, blood is viscous, and anatomy is complex. In this task, you will use ANSYS to compute pressure profiles in stenosis conditions for one of the major arteries.

Pre-Simulation Research

Before opening ANSYS, you must find and justify your simulation inputs from peer-reviewed literature.

1. **Anatomy:** Choose a specific artery (e.g., Common Carotid, Femoral, or Coronary). Find the typical **diameter** (D) and **inlet velocity** (V) for a healthy adult.
2. **Physiology:** Find the **Carreau-Yasuda** or **Power Law** viscosity coefficients for human blood. You cannot use the default "Water" or constant viscosity values for the Non-Newtonian part of this project.

The Simulation

You will perform a comparative study using **Steady-State Navier-Stokes** analysis.

Part 1: Severity Study (Geometric Sensitivity)

Create three geometries representing different levels of disease.

- **Model 1:** Healthy Artery (0% blockage).
- **Model 2:** Moderate Stenosis (50% reduction in cross-sectional area).
- **Model 3:** Severe Stenosis (75% reduction in cross-sectional area).
- **Condition:** Run these using standard **Newtonian Blood** properties ($\mu = 0.0035$ kg/m.s).

Part 2: The Rheology Study (Newtonian vs. Non-Newtonian)

Take your "worst-case" geometry (Model 3 - 75% Stenosis) and re-run it with a new material definition.

- **Model 4:** Severe Stenosis with **Non-Newtonian Blood** (using the coefficients you found in your research).

Please Note that ANSYS Student has some constraints:

- **Mesh Limit:** You have a 512,000-cell limit.
- **Solver:** Use the **Pressure-Based Solver** in ANSYS.
- **Turbulence:** Calculate your Reynolds Number (Re) at the throat of the stenosis. If Re > 2000, you must enable '**Turbulence'** model. If Re < 2000, use the '**Laminar'** mode in ANSYS.
  Note: Severe stenosis often triggers transition to turbulence.

Deliverables

Your final submission must be presented as a structured 2-3 pages report in addition to your simulation file(s). All scientific claims, parameter values, and model selections must be supported by properly cited research sources (e.g., journal articles, textbooks, or authoritative databases).
The report should contain the following sections:

Section A: Input Justification (With References)

Research-backed justification for all physiological and rheological inputs.

- **Artery Selection:**
  Explain why the chosen artery was selected and support its geometric and physiological properties with citations.
- **Blood Rheology:**
  Clearly justify the chosen viscosity model (Carreau or Power Law) using published parameter values
  All numerical inputs must be accompanied by references.

Section B: Geometric Analysis ("Young's Curve")

- Provide a plot of Pressure Drop (ΔP) vs. % Stenosis.
- Discuss whether the relationship is linear or nonlinear.

- Include a bio-implication discussion. Explain why this non-linearity makes sudden heart attacks difficult to predict based on mild symptoms.

Section C: Rheological Comparison

- Place the Velocity streamline images of Newtonian vs. Non-Newtonian (Model 3 vs Model 4) side-by-side.
- Look at the Recirculation Zone (the swirl immediately after the blockage). Does the Non-Newtonian viscosity make this zone longer or shorter?
- **Wall Shear Stress (WSS):** Plot the WSS along the arterial wall. Does the Newtonian assumption overestimate or underestimate the shear stress?
- Bio-Implication: Are low WSS regions prone to further plaque accumulation?

In all of the above, determine and state your assumptions and their potential modeling errors. Prove why simple math fails to predict pressure loss in a diseased (stenosed) artery.