Maddox Gonzalez
Gabriel Ospina

Fluent Flow 2D Simulation Assignment 1

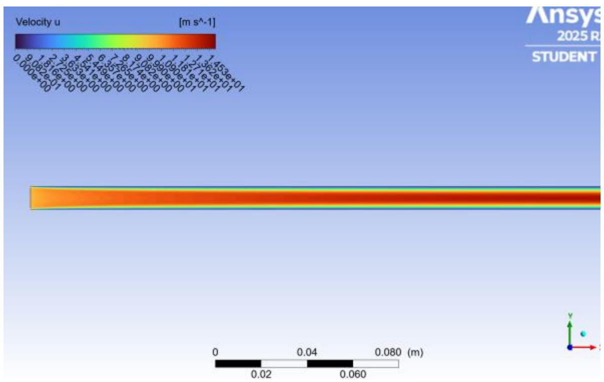
Fluid Mechanics EML 3701

Video Link:

https://www.youtube.com/watch?v=rsjHglyT7iI

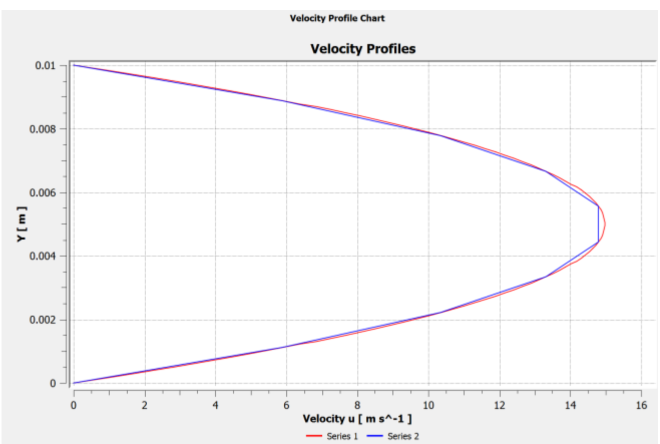
Case I. Poiseuille Flow

Figure 1: Velocity Contours for Poiseuille Flow



Viscosity of Air: 0.0001 $^{kg}/_{m \cdot s}$	
Density of Air: 1 $^{kg}/_{m^3}$	
Length: 1500 mm	
Height: 10 mm	
Inlet Velocity: 10 $^{m}/_{s}$	

Figure 2: Velocity Profile for Poiseuille Flow



Maximum Velocity and Location	
Velocity u ($^{m}/_{s}$)	Y (m)
Maximum Velocity: 15$^{m}/_{s}$	
Maximum Height: 0.005m	

(Eq. 1) Ratio for length: $L = 150h$

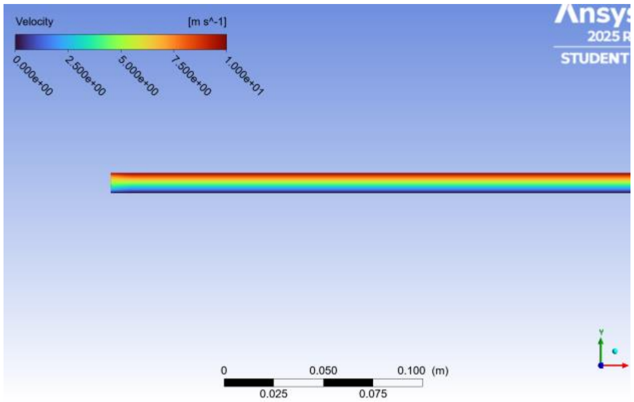
(Eq. 2) Reynold's Number: $Re = \frac{\rho v L}{\mu} = \frac{(1^{kg}/_{m^3})(10^{m}/_{s})(0.01m)}{(0.0001^{kg}/_{m \cdot s})} = 1000$

(Eq. 3) Laminar Flow Assumption: $^{L_c}/_{d} = 0.06Re_d = (0.06)(1000)(0.01m) = 0.6$

For case 1 of this project, the experiment has been set up to examine Poiseuille Flow. When accounting for Poiseuille Flow, the initial air flow is measured by the inlet velocity and later develops to have zero velocity near the walls due to the no slip condition, and greater velocity at the center due to the pressure gradients. The inlet velocity was set to $10 {}^{m}/_{s}$, and the viscosity of the air was selected to be $0.0001 {}^{kg}/_{m \cdot s}$, to create an acceptable Reynold's Number that simulated laminar flow and allows for a proper display of the shearing occurring by the walls of the pipe (Fig. 1). This developed flow forms a parabolic velocity profile (Fig. 2) that displays the change in velocity as the profile reaches the center of the pipe. The graph (Fig. 2) demonstrates a parabolic relationship where both the midline and endline values overlap. For this flow, the maximum velocity was observed to be $15 {}^{m}/_{s}$ at a height of $0.005m$, also seen as the intermediate height of the system.

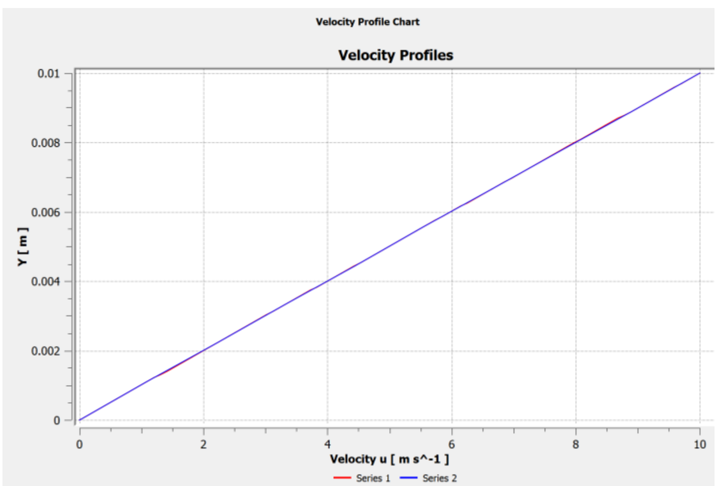
Case II. Poiseuille Flow

Figure 3: Velocity Contours for Poiseuille Flow



Viscosity of Air: 0.01 $^{kg}/_{m\cdot s}$
Density of Air: 1 $^{kg}/_{m^3}$
Length: 1500 mm
Height: 10 mm
Top Plate Velocity: 10 $^{m}/_{s}$

Figure 4: Velocity Profile for Poiseuille Flow



Maximum Velocity and Location	
Velocity u ($^{m}/_{s}$)	Y (m)
Maximum Velocity: $10^{m}/_{s}$	
Maximum Height: $0.01m$	

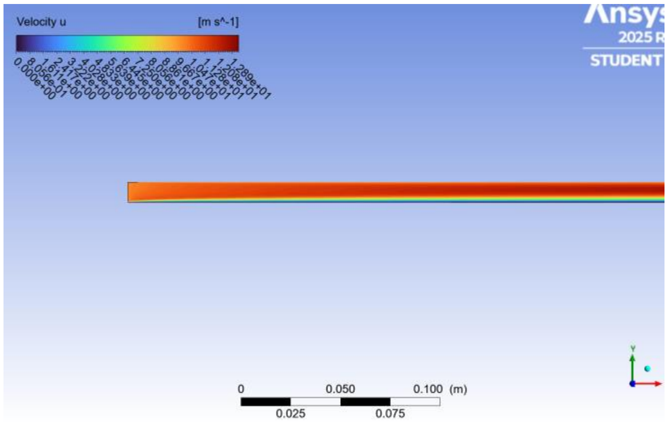
(Eq. 4) Ratio for length: $L = 150h$

(Eq. 5) Reynold's Number: $Re = \frac{\rho v L}{\mu} = \frac{(1^{kg}/_{m^3})(10^{m}/_{s})(1.5m)}{(0.01^{kg}/_{m\cdot s})} = 1500$

For case 2 of this project, instead of examining Poiseuille Flow, the experiment setup has been changed to Couette Flow. In which case, the inlet velocity is no longer a variable affecting the fluid's flow. Instead, the Couette Flow is examined under a pressure inlet, and the effects of an upper moving plate with a given velocity of $10^{m}/_{s}$, and a stationary bottom plate with no slip conditions. To attain proper laminar flow, the viscosity of the air was changed to $0.01^{kg}/_{m\cdot s}$, which resulted in a value of 1500 for Reynold's Number (Eq. 5). These alterations allowed for a proper observation of the shearing caused by the upper moving plate (Fig. 3). Once the velocity profile has developed, a linear relationship can be observed by both the midline and end line values (Fig. 4), which show the velocity increases to its maximum as the data reaches the top of the pipe (where the top plate is moving, therefore resulting in a fluid flow equal to approximately $0.99U_{max}$). For this flow, the maximum velocity was observed to be $10^{m}/_{s}$ at a height of $0.01m$, also seen as the maximum height of the system.

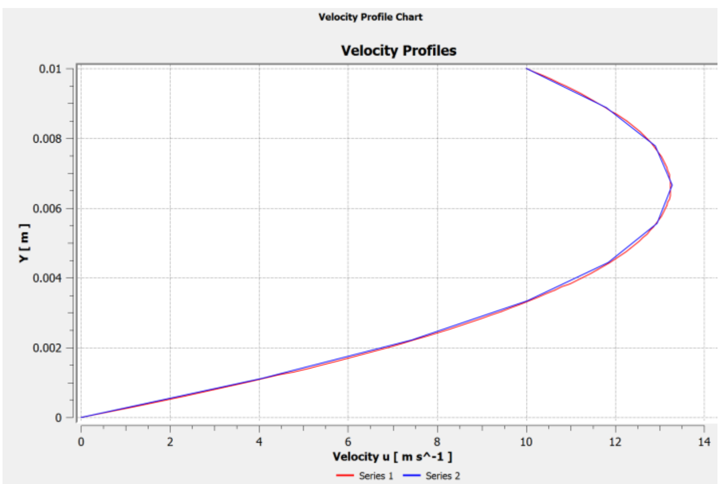
<u>Case III. Combination of Poiseuille + Couette flow</u>

Figure 5: Velocity Contours for Poiseuille Flow



Viscosity of Air: 0.0001 $^{kg}/_{m \cdot s}$	
Density of Air: 1 $^{kg}/_{m^3}$	
Length: 1500 mm	
Height: 10 mm	
Inlet Velocity: 10 $^{m}/_{s}$	
Upper Plate Velocity: 10$^{m}/_{s}$	

Figure 6: Velocity Profile for Poiseuille Flow



Maximum Velocity and Location	
Velocity u ($^{m}/_{s}$)	Y (m)
Maximum Velocity: 13.3$^{m}/_{s}$	
Maximum Height: 0.0063m	

(Eq. 6) Ratio for length: $L = 150h$

(Eq. 7) Reynold's Number: $Re = \frac{\rho v L}{\mu} = \frac{(1^{kg}/_{m^3})(10^{m}/_{s} + 10^{m}/_{s})(0.01m)}{(0.0001^{kg}/_{m \cdot s})} = 2000$

(Eq. 8) Laminar Flow Assumption: $^{L_c}/_{d} = 0.06Re_d = (0.06)(1000)(0.01m) = 0.6$

For case 3 of this project, instead of examining Poiseuille Flow or Couette Flow individually, the experiment has been set up to simulate the effects of air flow when it is under a hybrid flow of both Poiseuille and Couette Flow. In this case, the system is set up to have an inlet velocity of $10 {}^{m}/_{s}$, an upper moving plate set to move at $10 {}^{m}/_{s}$, and a stationary bottom plate. To maintain a proper laminar flow, the viscosity of the air was changed back to $0.0001 {}^{kg}/_{m \cdot s}$, which resulted in a value of 2000 for Reynold's Number (Eq. 7). These alterations allowed for an accurate observation of the shearing caused by the upper moving plate and the pressure gradient (Fig. 6), where it can be determined that the greatest shearing happens at the stationary wall. Once the velocity profile has developed, a skewed parabolic relationship can be observed by both the midline and end line values (Fig. 6), where it can be determined that the fluid reaches its maximum velocity slightly above the intermediate height of the pipe. For this flow, the maximum velocity was observed to be $13.3 {}^{m}/_{s}$ at a height of $0.0063m$.