Fluid Mechanics (ENGR30002)
2021 semester 1
Homework Assignment 2

Question 1 [60 marks]

Argon is flowing between two chambers through a 10 m horizontal pipe of internal diameter 15 mm. Absolute pressures in each chamber are measured to be 250 kPa and 103 kPa, respectively. The flow is isothermal at 50°C, the gas behaves ideally, the atomic weight of argon is 40 g/mol, and the friction factor (ϕ) is 0.001.

A. Determine the mass flow rate of gas and the gas velocities at the entrance and exit of the pipe.

(32 marks)

B. If the pressure in the downstream chamber is reduced while the upstream pressure is fixed, what is the maximum gas velocity achievable, and where in the pipe will it occur?

(8 marks)

C. Show that when this maximum velocity is reached, the upstream and downstream pressures are related by the following expression.

(14 marks)

$$8\phi\frac{L}{D}=\left(\frac{P_1}{P_2}\right)^2-\ln\left(\frac{P_1}{P_2}\right)^2-1$$

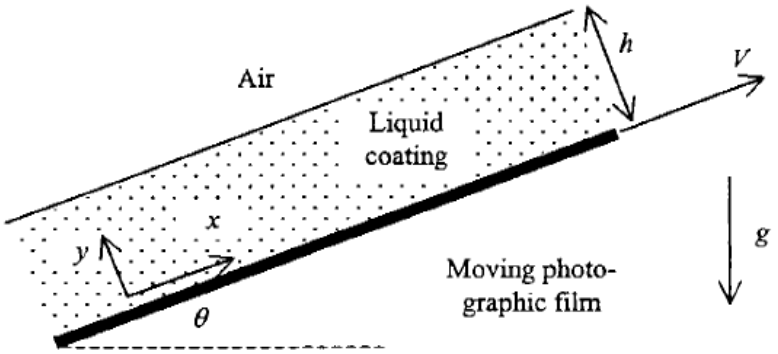
D. Describe what happens when the pressure in the downstream chamber is reduced below the value applicable under the conditions in part (c).

(6 marks)

(Total for Question 1 = 60 marks)

Question 2 (40 marks)

The diagram shows a coating experiment in which a flat film is being pulled up from a processing bath with a steady velocity V and an angle θ to the horizontal. As the film leaves the bath, it entrains some liquid which coats the film surface with a uniform thickness h. Assuming that the fluid flow is steady, independent of the z coordinate, Newtonian, and is directed parallel to the film. At the air-liquid interface, the shear stress is zero and the pressure is atmospheric.



A. Find an expression for the velocity profile v_x.

(26 marks)

B. Find an expression for the film thickness h when there is no net flow of liquid (i.e. as much liquid is being pulled up by the film as is falling back due to gravity).

(8 marks)

C. Sketch the velocity profile when there is no net flow of liquid and showing the velocity values at $y = 0$ and $y = h$.

(6 marks)

(Total for Question 2 = 40 marks)