Fluid Mechanics Homework #13

繳交期限：2019/1/4(六) 10:00 (不接受補交)

共五題，題號為：**9-87,88,90,91,98**

題號的對照書本是 **Yunus A. Cengel and John M. Cimbala "Fluid Mechanics: Fundamentals and Applications 3/e (SI Units) "**

9-87 Consider the following steady, two-dimensional, incompressible velocity field: $\vec{V} = (u, v) = (ax + b)\vec{i} + (-ay + cx^2)\vec{j}$, where a, b, and c are constants. Calculate the pressure as a function of x and y. *Answer:* cannot be found

Assumptions

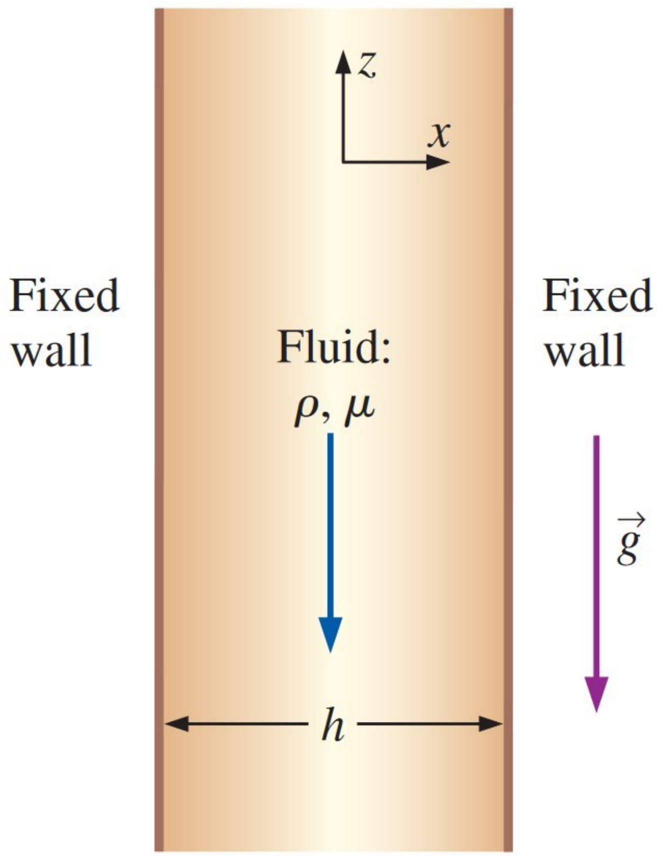
1 The flow is steady.

2 The flow is incompressible.

3 The flow is two-dimensional in the xy-plane.

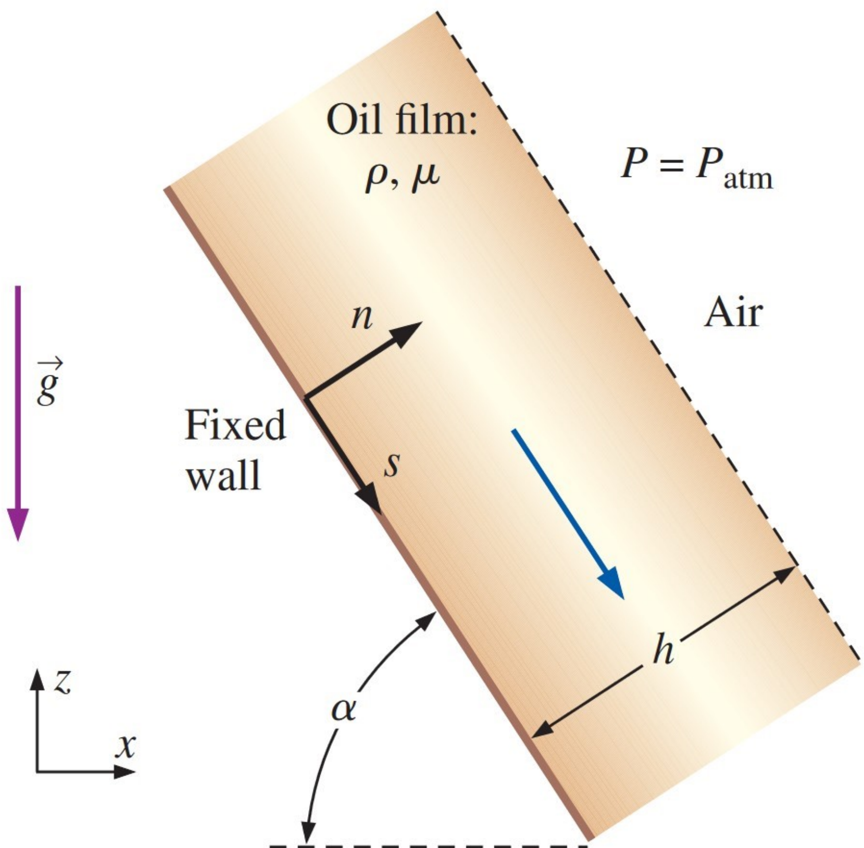
4 Gravity does not act in either the x- or the y-direction.

9-88 Consider steady, incompressible, parallel, laminar flow of a viscous fluid falling between two infinite vertical walls (Fig.P9-88). The distance between the walls is h, and gravity acts in the negative z-direction (downward in the figure). There is no applied (forced) pressure driving the flow—the fluid falls by gravity alone. The pressure is constant everywhere in the flow field. Calculate the velocity field and sketch the velocity profile using appropriate nondimensionalized variables.



Assumptions We number and list the assumptions for clarity:
1 The walls are infinite in the yz-plane (y is into the page).
2 The flow is steady, i.e. time derivatives of any quantity are zero.
3 The flow is parallel (the x-component of velocity, u, is zero everywhere).
4 The fluid is incompressible and Newtonian, and the flow is laminar.
5 Pressure $P = constant$ everywhere. In other words, there is no applied pressure gradient pushing the flow; the flow establishes itself due to a balance between gravitational forces and viscous forces.
6 The velocity field is purely two-dimensional, which implies that $v = 0$ and all y derivatives are zero.
7 Gravity acts in the negative z direction. We can express this mathematically as $\vec{g} = -g\vec{k}$

9-90 Repeat Example 9–17, except for the case in which the wall is inclined at angle α (Fig. P9–90). Generate expressions for both the pressure and velocity fields. As a check, make sure that your result agrees with that of Example 9–17 when $\alpha = 90°$. [*Hint*: It is most convenient to use the (s, y, n) coordinate system with velocity components (u_s, v, u_n), where y is into the page in Fig. P9–90. Plot the dimensionless velocity profile u_s^* versus n^* for the case in which $\alpha = 60°$.]



Assumptions We number and list the assumptions for clarity:

1 The wall is infinite in the sy-plane (y is out of the page for a right-handed coordinate system).

2 The flow is steady

3 The flow is parallel and fully developed (we assume the normal component of velocity, u_n, is zero, and we assume that the streamwise component of velocity u_s is independent of streamwise coordinate s).

4 The fluid is incompressible and Newtonian, and the flow is laminar.

5 Pressure $P = constant = P_{atm}$ at the free surface. In other words, there is no applied pressure gradient pushing the flow; the flow establishes itself due to a balance between gravitational forces and viscous forces along the wall. Atmospheric

pressure is constant everywhere since we are neglecting the change of air pressure with elevation.

6 The velocity field is purely two-dimensional.

7 Gravity acts in the negative z direction. We can express this mathematically as $\vec{g} = -g\vec{k}$ In the sn-plane, $g_s = gsin\alpha$ and $g_n = -gcos\alpha$.

9-91 For the falling oil film of Prob. 9-90 , generate an expression for the volume flow rate per unit width of oil falling down the wall ($\dot{V}/L$) as a function of ρ, μ, h, and g. Calculate ($\dot{V}/L$) for an oil film of thickness 5.0 mm with ρ = 888 kg/m^3 and μ = 0.80 kg/m·s.

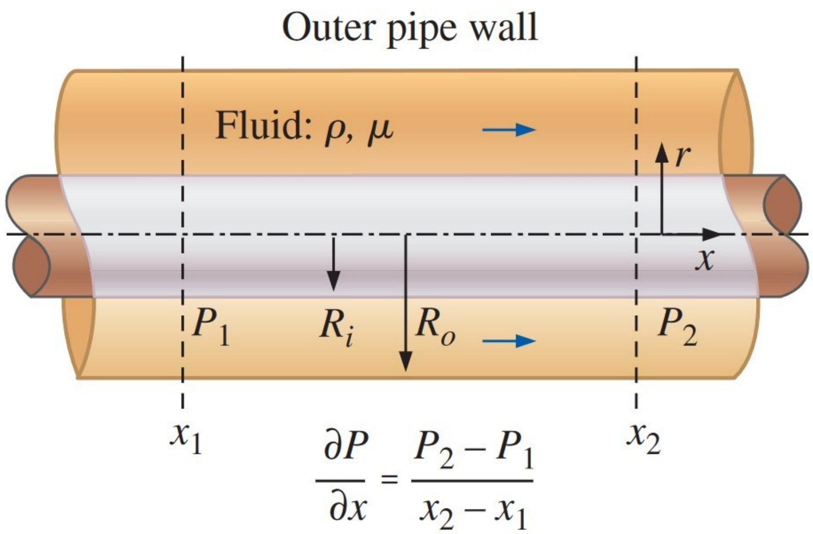
Assumptions

1 The flow is steady.

2 The flow is incompressible.

3 The wall is infinitely wide and very long so that all of the parallel flow, fully developed approximations of Problem 9-90 hold

9-98 Consider steady, incompressible, laminar flow of a Newtonian fluid in an infinitely long round pipe annulus of inner radius R_i and outer radius R_o (Fig. P9-98). Ignore the effects of gravity. A constant negative pressure gradient $\partial P/\partial x$ is applied in the x-direction, $(\partial P/dx) = (P_2 - P_1)/(x_2 - x_1)$, where x_1 and x_2 are two arbitrary locations along the x-axis, and P_1 and P_2 are the pressures at those two locations. The pressure gradient may be caused by a pump and/or gravity. Note that we adopt a modified cylindrical coordinate system here with x instead of z for the axial component, namely, (r, θ, x) and (u_r, u_θ, u). Derive an expression for the velocity field in the annular space in the pipe.



Assumptions We number and list the assumptions for clarity:

1 The pipe is infinitely long in the x direction.

2 The flow is steady.

3 This is a parallel flow (the r-component of velocity, u_r, is zero).

4 The fluid is incompressible and Newtonian, and the flow is laminar.

5 A constant pressure gradient is applied in the x direction such that pressure changes linearly with respect to x according to the given expression.

6 The velocity field is axisymmetric with no swirl.

7 We ignore the effects of gravity.