Part 1. Microscopic Conservation of Momentum and the Navier-Stokes equations

1. What is the difference between body forces and surface forces?

Body forces act on the center of an object like gravity, surface forces act on the surface like pressure and shear force. Surface forces depend on both the surface acted on and the direction that force is applied in and are expressed in a stress tensor.

1. What is a generalized stress and how is it written with respect to the normal and force directions?

General stress is a tensor used to represent surface forces

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The diagonal forces are in the normal direction (pressure) and the others are shear forces. Remember that the format for tau vectors is 1st: the normal of the surface being acted on, and 2nd: the direction of the force.

1. What is the difference between shear stresses and normal stresses?

Normal forces act parallel to the normal of the surface and shear forces don’t

1. What is momentum flux and what are its units?



It has units of M/L t2 (which is the same as pressure)

1. How is the Product Rule used to express partial derivatives?

 <- That is product rule

It turns This:



Into



1. What are the Cauchy Momentum equations?

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1. What are the Navier-Stokes equations? When can it be used and what do each of the terms mean?

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**Assumptions are incompressible and Newtonian Flow**

Left-hand side is momentum change, right-hand side consists of pressure force, gravitational force and viscous forces

1. What is the Substantial Derivative and how is it written?

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*Derivative following motion of a fluid element*

1. Determine how to evaluate if a given velocity field satisfies the continuity equation in Cartesian and cylindrical coordinates.

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Use this

Part 2. Application of the Navier-Stokes equations

1. What is the general solution procedure for using the Navier-Stokes equations to solve Newtonian flows?
   1. Choose coordinate system, find out which direction the flow is in, find out in which direction the velocity changes
   2. Determine the driving force
   3. Identify boundary conditions
   4. Simplify conservation equations (Navier-Stokes and continuity if necessary)
   5. Solve the differential equation for the velocity
2. What kinds of driving forces can generate flows?

Pressure, Shear forces, gravity

1. How is the Pressure Drop typically defined?

dP/d<direction> is point 2 – point 1, but pressure drop (deltaP) is defined as P1-P2, so the partial equals negative deltaP over the length

1. What kinds of boundary conditions are applied in each case?

Well, you can have boundary conditions at walls where the velocity is 0, you can have flows that are in contact with the air, where that is a maximum velocity, and thus the change in velocity with respect to your normal of the surface of the flow is 0, with moving plates you could have a flow that is moving at the same velocity as your plate.

1. What is the difference between a no-slip and a free-surface boundary condition?

In no-slip, your flow is moving at the same speed as your boundary, and for free-surface, there is no stress acting on the boundary, so the change in velocity is 0.

1. Given the equation for the velocity distribution in pipe flow, how are the average velocity, volume flow rate, and wall shear stress obtained?

Q is just Vavg \* A

For wall shear stress, you need to select the correct tau value from the tensor, then you need to find it using the weird newton’s law of viscosity thing

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1. What is the Hagen-Poiseuille Equation and when can it be used?

, same conditions as Navier-stokes (incompressible and Newtonian). Good for laminar flows

1. What is scaling analysis? How can it be used to match conditions in different flows?

Changing the N-S equations to be expressed where it can be scaled easily???

1. What is the Reynolds number? What forces does it express the relative magnitude of?

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Ratio of inertial forces to viscous forces.

Part 3. Conservation of Energy, Bernoulli’s Equation with Losses, Reynolds number and Turbulence

1. How can Bernoulli’s equation be modified to include viscous losses (lv) and mechanical energy input (ws)?
2. Explain Osborn Reynolds’ experiments and how they identified different flow regimes in pipe flow.
3. What is the difference between laminar and turbulent flow? What is the critical range of values of Re associated with these transitions in pipe flow?
4. What is the relationship between viscous losses and shear stress at the wall?

Part 4. Pipe flow network analysis

1. What is the definition of the friction factor f. How is it related to the loss coefficient K? What is the difference between Fanning and Darcy friction factors?
2. What is the relationship between f and Re for laminar and turbulent flow in a smooth walled pipe?
3. What is meant by pipe schedule, and how is the schedule number determined?
4. What is the Moody diagram? How is it used?
5. What are some other methods for calculating friction factors in a pipe?
6. Write expressions for the Reynolds number in terms of average velocity, volume flow rate, mass flow rate.
7. What is the hydraulic diameter? How is it calculated? How is the hydraulic diameter accounted for in solving problems involving non-circular pipes?
8. What are the Driving Force Terms of the Bernoulli’s Equation?
9. When are kinetic energy changes typically neglected?
10. For pipe flow, how is the viscous losses term (lv) related to the pipe friction factor f?
11. What is the difference between actual pump power and ideal pump power, and how are these each calculated?
12. How is pump head calculated?
13. What are the general solution procedures for solving steady flow rate pipe flow problems?
14. What is the difference between major and minor losses in pipe flow?
15. How are viscous losses calculated when valves and fittings are present in the pipe flow network?
16. What is the equivalent L/D method, the Crane method, and the 3-K method?
17. How would you determine the relative frictional losses when comparing different types of valves and fittings?
18. What are the general solution procedures for solving steady flow rate problems for pipe networks containing fittings?