Study Guide for CM3110
Module 2 Fluid Mechanics Introduction
Morrison Spring 2021

Test subjects in this course are cumulative. Anything on a study guide from a prior exam may be the subject of a current exam.

Exam 2 will cover, in addition to Exam 1 topics, Newton's law of viscosity, Newtonian constitutive equation, microscopic momentum balance, momentum boundary conditions, velocity and stress profiles, and fluid mechanics troubleshooting.

<u>To do well on the test, you should be able to do the following:</u>

Material and system properties for flow

1. Define <u>fluid shear stress</u> and explain the role of this quantity in fluid flow; compare and contrast fluid shear stress with pressure
2. (stretch) Compare and contrast normal and tangential stresses
3. (stretch) Compare and contrast isotropic and anisotropic stresses

Transport law: Newton's law of viscosity/Newtonian constitutive equation

4. Define <u>viscosity</u> and explain how this quantity influences the flow behavior of fluids
5. Calculate momentum flux (shear stress) from velocity gradient (shear rate) and vice versa using Newton's law of viscosity
6. Define the Newtonian constitutive equation and explain its purpose
7. Calculate the stress tensor $\underline{\underline{\tilde{\Pi}}}$ for a flow when the velocity field $\underline{v}$ is known
8. (stretch) In general terms, explain how non-Newtonian fluids may be different from Newtonian fluids
9. List examples of Newtonian fluids; (stretch) list examples of non-Newtonian fluids

Velocity and stress profiles. If provided with a one-dimensional or two-dimensional velocity profile (also called a velocity distribution or the velocity field):

10. Sketch the velocity profile or the velocity vector field
11. Calculate the fluid volumetric flow rate through a chosen surface
12. Calculate the average fluid velocity over a chosen surface
13. Calculate the maximum fluid velocity within a chosen region

Microscopic momentum balance

14. Define the continuity equation and the Navier-Stokes equation and explain their utility
15. Compare and contrast the conservation of momentum equation and the Newtonian constitutive equation
16. For a chosen flow scenario, list, and justify reasonable modelling assumptions that will allow the velocity and stress fields to be determined

17. For a chosen flow scenario, calculate the velocity and stress fields. You must be able to indicate your assumptions and to show how you arrive at your answer from the principles discussed in the course

Boundary conditions and engineering quantities of interest (fluid momentum)

18. Explain the role that velocity and pressure boundary conditions play in fluid-mechanics modeling
19. Identify appropriate velocity and pressure boundary conditions for a flow scenario described
20. In detailed mathematical form identify appropriate velocity/velocity gradient and pressure boundary conditions for a flow scenario described
21. From the velocity and stress fields in a given flow scenario, calculate the force $\underline{\mathcal{F}}$ on a chosen surface
22. From the velocity field in a given flow scenario, calculate the volumetric flow rate Q and average velocity $\langle v \rangle$ through a chosen surface
23. (stretch) From the velocity and stress fields in a given flow scenario, calculate the torque $\underline{\mathcal{T}}$ on a chosen surface

Fluid mechanics troubleshooting

24. From among fluid mechanics tools (fluid statics, mechanical energy balance, microscopic momentum balance, other) identify the method that will result in the missing desired quantity (pressure drop, shaft work, frictional losses, flow rate, velocity profile, drag, force on the wall, (stretch) torque, (stretch) rotational speed, terminal velocity, pump efficiency, etc.)
25. List, in an order that works, steps for determining a quantity with the fluid mechanics tools at your disposal