Chemical Engineering 374

Fluid Mechanics
Fall 2014

Final Review (from Exam 3 on)

Spiritual Thought

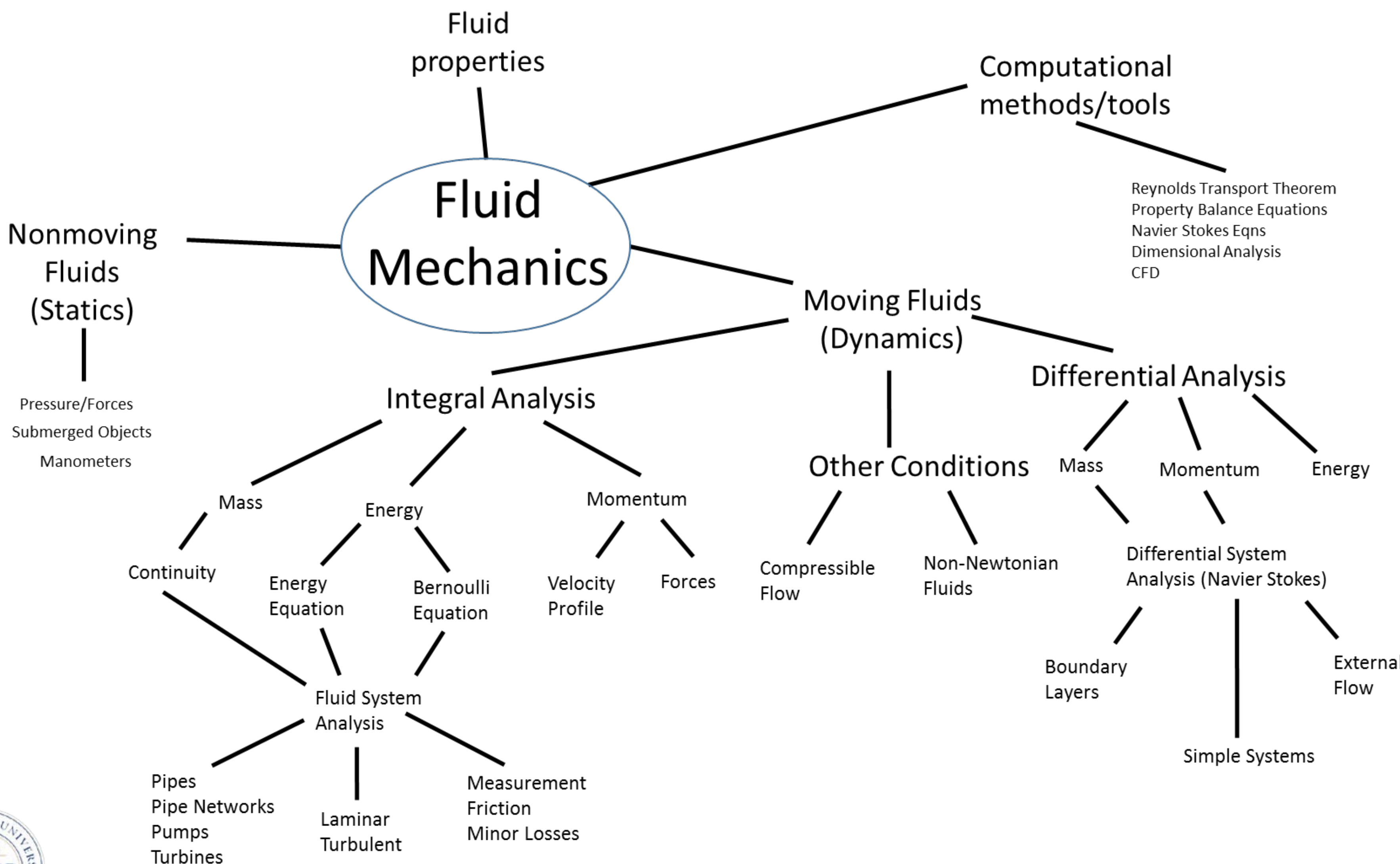
Face the future with optimism. I believe we are standing on the threshold of a new era of growth, prosperity, and abundance. Barring a calamity or unexpected international crisis, I think the next few years will bring a resurgence in the economy as new discoveries are made in communication, ***medicine***, ***energy***, ***transportation***, physics, ***computer technology***, and ***other fields*** of endeavor.

Many of these discoveries, as in the past, will be ***the result of the Spirit whispering insights into and enlightening the minds of truth-seeking individuals***. Many of these discoveries will be made for the purpose of helping to bring to pass the purposes and work of God and the quickening of the building of His kingdom on earth today. With these discoveries and advances will come new employment opportunities and prosperity *for those who work hard and especially to those who strive to keep the commandments of God*. This has been the case in other significant periods of national and international economic growth.

-Elder M. Russell Ballard

BYU Idaho Commencement Remarks

April 6, 2012


Fluid properties
Computational methods/tools
Reynolds Transport Theorem
Property Balance Equations
Navier Stokes Eqns
Dimensional Analysis
CFD
Fluid Mechanics
Nonmoving Fluids (Statics)
Pressure/Forces
Submerged Objects
Manometers
Moving Fluids (Dynamics)
Integral Analysis
Mass
Continuity
Energy
Energy Equation
Bernoulli Equation
Momentum
Velocity Profile
Forces
Fluid System Analysis
Pipes
Pipe Networks
Pumps
Turbines
Laminar
Turbulent
Measurement
Friction
Minor Losses
Other Conditions
Compressible Flow
Non-Newtonian Fluids
Differential Analysis
Mass
Momentum
Energy
Differential System Analysis (Navier Stokes)
Boundary Layers
Simple Systems
External Flow

Exam 1

- Classes 1-9 (plus review)
- Chapter 1 — Introduction/Basics
- Chapter 2.1-2.6 — Fluid Properties
- Chapter 3.1-3.6 — Pressure/Fluid Statics
- Chapter 4.1, 4.6 — RTT, Conservation Laws
- Chapter 5.1-5.5 — M.B., E.B., Bernoulli
- Homeworks 1-9

Exam 2

- Classes 13-21
- Chapter 5.6 Mechanical Energy
- Chapter 7.1-7.5 Dimensional Analysis
- Chapter 8.1-8.8 Pipe Flows
  - Laminar
  - Turbulent
  - Minor Losses
  - Single Pipelines
  - Pipe networks
  - Flow measurement

Exam 3

- Classes 25-32 (plus review)
- Chapter 6.1-6.4 Momentum Balance
- Chapter 9.1-9.2, 9.4-9.6 Differential Balances
- Chapter 10.6 Boundary Layers
- Chapter 14.1-14.5 Pumps and Turbines
- HW 19-26

Final Exam

- All previous material plus:
- Classes 36-39
- Notes Non-Newtonian Flow
- Chapter 12 Compressible Flow
- Chapter 15 CFD
- HW 27, 28

Class 36—Non-Newtonian Flow

- Types of NN fluids and examples
- Power law fluids—Form of tau
- Laminar pipe flow
  - Redo equations for a new tau expression
    - Important themselves, and to get Re and f expressions.
  - Define Re as 64/f,
- A non-Newtonian "Moody" chart
- Analyse as for Newtonian flows
- Rhelological parameters (get the K and n)

Class 37—Compressible Flows

- Sound speed: derivation and equation:

  c=sqrt(kRT/M)
- T, P, rho expressions for compressible flows versus speed (Mach number).
  - Found using an energy balance from a reservoir.
- Flow in nozzles: mdot = rho*A*v
  - Mach > 1 requires a diverging nozzle for increasing speed.
  - Area versus flow in a nozzle
- Choked flow: pressure ration = 0.53

Class 38-39—CFD Intro

- Know material covered by the book/reading questions
  - 15.1, 15.3
  - Grid types and properties
  - Boundary conditions
- Turbulent simulation approaches: RANS, DNS, LES
  - Why are turbulent flows hard to simulate
  - Most popular turbulence model for RANS = k-epsilon
- Example solution of unsteady 1-D laminar flow
- Example of a 2-D laminar jet and lid-driven cavity
- Turbulence → average properties → term for the unresolved fluctuations → require “closure” (meaning writing the <v’v’> average term in terms of things we are solving (v average). → turbulent viscosity → k-epsilon model.

Example Problem 1

(d) You are James Bond, urbane British spy working in her majesty's secret service. While flying over Eastern Asia, you are ambushed by Russian fighter jets, and are forced to jump out of the soon to explode plane. All too late, you discover that your parachute is broken. Thinking quickly, you scan the ground and discover 7 different options for where to land: **a lake, a very wide pool of quicksand, a large tarpit, a huge sewage pool, a wide mud pit, a massive commercial melted-polymer storage pool** (the pools are all very deep, just like the lake), **or the ground.**

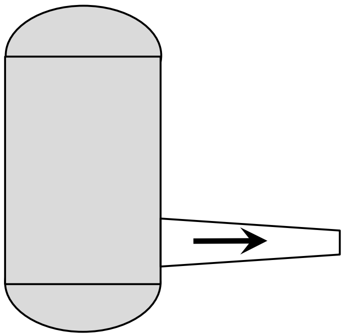
i) Which 2 options give the highest chance of surviving the impact, ***and why?***

(HINT – I'm looking for specific justification based on a recently learned fluids principle, not just a guess, or a hypothetical.)

ii) Of the two options listed in part i), which one gives the greatest chance of survival after you've landed, **and why?**

Example Problem 2

- Consider compressible flow of air from a reservoir at 400 K and 6 atm. The air flows through a linearly converging nozzle 10 cm long into the atmosphere (at 300 K and 1 atm). The nozzle area starts at 10 cm^2, and ends at 2 cm^2.
  - Find the **mass flow rate** and **volumetric flow rates** through the nozzle.
  - If the pressure in the vessel were decreased to 3 atm at the same temperature, would the **volumetric flow rate** increase, decrease, or stay the same?
  - If the pressure in the vessel were decreased to 3 atm at the same temperature, would the **mass flow rate** increase, decrease, or stay the same?



Example Problem 3

At sea level, the temperature and pressure are 300 K and 101325 Pa. Compute the pressure at the top of Mount Everest (elevation 8848 m). Assume an adiabatic atmosphere with temperature given by $T = T_0(P/P_0)^{0.28}$, where T_0 and P_0 are at sea level.

OEP Example

The good sailors on U-571 were in a desperate situation, with a German destroyer bearing down on them with guns blazing. After some heroic sacrifices, the pressure in the torpedo tube was fully restored (39 kg_f/cm^2, if you missed it on the gauge in the movie). They were then able to fire the torpedo at the destroyer. In reality, the destroyer could have avoided the torpedo by changing course. How much ***time*** did the Germans have from the moment the torpedo was fired to avoid impact? ***Do not assume an initial torpedo speed***… that is something you must calculate!!!! (hint – DO NOT count the seconds on the movie and use that for an answer… movie time is distorted)

- Verify your answer... Does it look reasonable? Anything odd about the calculation?
- a) Re-evaluate the answer in part 6 assuming that the torpedo accelerates/decelerates in the water. Use reasonable assumptions for the acceleration of a WWII torpedo and check your answer from part 6.
- b) How would this answer change if U-571 was fleeing at full speed away from the German destroyer? How would it change if the submarine was charging the destroyer?
- c) based on your evaluation in part 7a, calculate the energy required to accelerate/decelerate the torpedo (make an assumption about motor efficiency).
- d) In your estimation, was this enough time for the Germans to avoid the torpedo? (justify this answer based on the work you've done for the problem)