Department of Mechanical Engineering
MECH 222 (with MECH 225 & MATH 253): Engineering Science II
2015W

Summary: Fluid properties, equations of state and use of thermodynamic property tables. Pressure, buoyancy, hydrostatic forces, pressure measurement. Conservation of mass, momentum, and energy. Bernoulli's equation. Dimensional analysis, modeling. Turbulent flow in pipes; turbomachinery. Work and heat; internal energy and enthalpy. Second law and the Carnot cycle; entropy; first and second law analysis of systems. Partial and directional derivatives; maxima and minima; Lagrange multipliers and second derivative test; multiple integrals and applications.

LEARNING OBJECTIVES

The calendar descriptions do not convey the real emphasis of the course, which is defined more clearly in the learning objectives. Equal weight is given to the topics of fluid mechanics, thermodynamics and mathematics theory and problem solving.

For Fluid Mechanics, by the end of the course, you should be able to:

- Explain what causes pressure in a fluid.
- Calculate how pressure varies with depth in a stationary fluid.
- Calculate force and moment due to pressure on a submerged surface.
- Describe buoyant force and apply it for submerged and floating bodies.
- Explain why and when control volume analysis is used in fluids and thermo.
- Select an appropriate control volume.
- Apply control volume analysis of mass and momentum conservation to solve problems in steady and unsteady fluid mechanics and thermodynamics.
- Correctly apply Bernoulli's equation.
- Find the non-dimensional parameters for a problem, given a list of relevant dimensional parameters.
- Apply scaling to predict full-scale behavior from experimental data on a model.
- Describe the fundamental differences between laminar and turbulent flow.
- Use the Moody diagram to determine pressure loss in a fully-developed pipe flow.
- Account correctly for minor losses in a pipe system.
- Determine a system curve for a pipe system.
- Use a pipe system curve and pump performance data to predict performance and select an appropriate pump.

For Thermodynamics, by the end of the course, you should be able to:

- Define a thermodynamic system and its boundary interactions
- Apply the First Law of Thermodynamics to both 'closed' and 'open' systems.
- Describe the implications of the Second Law of Thermodynamics and entropy generation
- Calculate entropy change for 'open' and 'closed' systems.
- Perform a cycle analysis for ideal power generation and refrigeration cycles

For Mathematics, by the end of the course, you should be able to:

- Express curves, surfaces, and solids in space using functions, equations and inequalities.
- Visualize functions, equations, and inequalities using curves, surfaces, and solids.
- Make local linear approximations to functions, and visualize them geometrically.
- Find local maximum and minimum values for a given function of several variables, and apply this skill in practical problems.
- Set up single, double, and triple integrals that represent length, work, area, volume, force, flux, and other physical quantities.
- Evaluate such integrals, both analytically and numerically.
- Use partial derivatives and appropriate integrals to analyze time-varying processes (like flying point particles or flowing fluids) in space.
- Exploit vector extensions of the Fundamental Theorem of Calculus to solve problems involving work, potential, and fluid flow.

COURSE DETAILS

Course information including schedule, textbooks, notes, labs, tutorials, and fieldtrips are posted on **Connect** under the Mech 2 site. You can access Connect from your UBC student account using your campus wide login.

Course notes are available on Connect.

Problem sets will be posted on Connect each **Tuesday**. They are completed on Connect and are due one week later, on the following **Tuesday at 8:00 am**.

In addition to the marked problems, "practice problems" will be posted to the MECH 222 page of Connect. These additional problems will **not** be marked and you do not need to submit solutions. However, similar problems may well show up on quizzes.

CONNECT WILL NOT ACCEPT LATE PROBLEM SETS SUBMISSIONS.

Attendance at all Tutorials is Strongly Recommended. It is important to arrive on time; latecomers will not be admitted. Please refer to the policy in the Mech 2 Handbook.

Weekly tests, field trips, and special lectures are scheduled on Thursdays. Weekly tests are scheduled at 8:00-11:00 on Thursdays. Some tests will be followed by Special Lectures from leading engineers on topics pertinent to Mech 2. These will be announced ahead of time. **Attendance and respectful behaviour to our guests are required at all of these activities.**

Office Hours for each instructor in Mech 2 are posted on the Connect site.

Academic standards. Mech 2 is a professional program and you are expected to meet the academic and professional standards of the university. Academic misconduct of any kind will not be tolerated. You are advised to review the Rules and Regulations for Mech 2 as linked to the Connect site.

GRADING POLICIES

Engineering Science II appears on your transcript as three courses for administrative reasons, but they are graded together and if you successfully complete all course requirements you will receive the same from for MECH 222, MATH 253, and MECH 225.

To pass Engineering Science II (MECH 222, MATH 253, MECH 225), you must satisfy all three of the criteria listed below:

1. **Pass the exams (50%) in every subject area.**
    - This is the weighted average of all weekly tests and finals in the subject area, with a weighting of 40% tests and 60% finals.
    - You do not need to pass each individual test or final, but the weighted average of all tests and finals in any given subject area must be ≥50%. It is possible to fail an individual test or final and still achieve ≥50% for your exams grade in that subject area.
    - Each of the three subjects is calculated separately – fluids, thermodynamics, and multivariable calculus.

2. **Have an overall exam grade (the combined grade of the exams for all subjects) of at least 40 out of 80 (50%).**
    - The overall exam grade is worth 80% of the overall course grade (see criterion 3 below). Each subject (Fluids, Thermodynamics, Multivariable Calculus) is weighted evenly.

3. **Have an overall course grade (including problem sets, labs, etc.) ≥50%.**
    - The grading scheme is as follows:
        - Weekly problem sets: 5%
        - Labs and field trips: 15%
        - Overall exams: 80%

There are therefore 3 separate grading levels that a student must pass in order to pass all of Engineering Science I, as reflected in the following table.

Table 1: Engineering Science I (MECH 222 / MATH 253 / MECH 225) Grade Calculations

Level	Grade type	Calculation	Required result
1	Subject exams grade	(Subject Tests * 40%) + (Subject Finals * 60%)	≥50 for each subject
2	Overall exams grade	([Fluids exams grade + Thermo exams grade + Multivariable Calculus grade] / 3) * 80%	≥40
3	Overall course grade	(Problem sets * 5%) + (Labs and field trips * 15%) + (Overall exams grade)	≥50

Students who do not meet the required result at any of the 3 levels will be assessed a final grade according to Table 2.

Final Grades for MECH 222, MATH 253, and MECH 225

Since a student may not pass Engineering Science II without satisfying all three criteria, a student's final grade for the course may not necessarily equal the calculated overall course grade (which could exceed 50% even if multiple subject areas are less than 50%). Students are therefore first assessed on a pass/fail basis according to the criteria in Table 1, and, based on that assessment, given a final grade according to Table 2 below.

If a student does not pass Engineering Science II due to failing in one subject area (i.e. the student meets criteria 2 and 3 but not criterion 1), a special leniency will be granted for the student to remediate the deficient coursework (see the Mech 2 Remediation Policies posted on Connect for more information). The student must remediate this course to graduate and, in many cases, to move on to subsequent coursework.

Table 2: Engineering Science I (MECH 222 / MATH 253 / MECH 225) Grade Results

Subject Exams Grade	Overall Exams Grade	Overall Course Grade	Pass/Fail	Final Grades: MECH 221 MATH 255	Final Grade: MECH 224
All subjects ≥ 50%	≥ 50%	≥ 50%	Pass	Overall Course Grade	Overall Course Grade
1 subject < 50%	< 50%	irrelevant	Fail	Overall Exams Grade	Overall Exams Grade
	irrelevant	< 50%	Fail	Overall Course Grade	Overall Course Grade
	≥ 50%	≥ 50%	Leniency (Pass 222/253; Fail 225)	Overall Course Grade	Subject Exams Grade of Highest Failed Subject
2 or more subjects < 50%	irrelevant	irrelevant	Fail	Average of Failing Subject Exam Grades	Average of Failing Subject Exam Grades

THE MECH 2 "TOP TEN" PRINCIPLES FOR SUCCESS

The following ten principles for success have been carefully selected based experiences of students in previous years and our observations. We strongly encourage you to develop and to apply these principles towards your studies in MECH 222 and future courses:

1. **Transference**: students must be able to apply and combine concepts in new ways they have not seen before

2. **Schematic Representations**: students must be able to construct and use free-body diagrams, control volumes, and other schematic representations; students must be able to create and use mathematical models of physical systems

3. **Communication**: students must be able to clearly express ideas in an orderly and logical way using written, graphical, and oral forms

4. **Solution paths**: students must be able to identify the major steps in a solution (or structured code) before beginning computation/coding of the solution; students must understand that there may be more than one method to find a solution

5. **Assumptions**: students must be able to determine appropriate assumptions and clearly articulate them when formulating a solution

6. **Justification**: students must be able to use engineering principles to support and justify decisions, approaches, and recommendations

7. **Estimation/order-of-magnitude**: students must be able to estimate approximate engineering quantities when faced with incomplete information; students must be able to judge the validity of a result after completing a calculation

8. **Dimensional consistency**: students must know the dimensions of common engineering parameters and be able to identify dimensionally consistent / inconsistent equations

9. **Reference quantities**: students must be able to identify real-world reference values for common physical quantities (including reference values for length, speed, mass, force, energy, and power)

10. **Significant figures**: students must express numerical quantities with an appropriate number of significant digits

Best of luck in MECH 222!