Department of Mechanical Engineering
MECH 221 (with MECH 224 & MATH 255)

Engineering Science I

Calendar Description: Rigid body kinetics and kinematics, basic electrical circuits, work and power, stress and strain, torsion, bending, engineering materials, probability and statistics. This course includes the content of EECE 263.
Prerequisites: MATH 101, MATH 152, PHYS 153, PHYS 170
Corequisites: ENGL 112, MECH 220
Credits: MECH 221 (12) + MECH 224 (1) + MATH 255 (3)

LEARNING OBJECTIVES

In this course, you will cover the topics of differential equations, dynamics, electric circuits, materials, and solid mechanics. This document gives details of the course beyond the brief description in the UBC Calendar. In addition to the detailed objectives, an overall objective of MECH 221 is that you should be able to integrate the concepts from the different subjects to work effectively on multi-disciplinary engineering problems.

For **Differential Equations**, by the end of the course, you should be able to:

- Numerically represent a function and perform numerical integration
- Identify, set up, and solve first order differential equations, including numerical approximations, autonomous equations and stability, and the integrating factor method
- Identify, set up, and solve second order differential equations with applications to oscillations (electrical and mechanical)
- Identify, set up, and solve systems of linear differential equations
- Calculate Laplace transforms and inverses from tables, and use these to solve differential equations with discontinuous forcing

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

- Describe 2-D motion of rigid bodies, and compute velocities and accelerations of any point on a rigid body.
- Compute inertial (d'Alembert) forces and moments of a rigid body.
- Compute applied forces and moments, to balance inertial forces and moments for a rigid body.
- Compute kinematic and kinetic (motion, force and moment) values for a moving body from momentum and energy relationships (and vice-versa).
- Model and analyze the vibration of a one-dimensional system.

For **Electric Circuits**, by the end of the course, you should be able to:

- Describe an electric circuit in terms of commonly used variables.
- Analyze an electric circuit constructed with passive elements (resistors, capacitors and inductors), independent and dependent sources, and operational amplifiers.
- Apply Ohm's and Kirchhoff's Laws, nodal and loop analysis, in analyzing circuits.
- Apply circuit theorems (superposition, Thevenin, Norton, and maximum power transfer).
- Analyze first and second-order transient circuits, steady-state AC circuits, and variable-frequency networks.
- Describe the phenomenon of resonance and the use of passive and active filters.

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

- Apply the fundamental concepts in Solid Mechanics:
  - equilibrium, compatibility and material behaviour;
  - normal and shear stress;
  - stress concentration;
  - factor of safety.
- Describe multiaxial stresses and strains, Hooke's Law, Poisson's ratio, St. Venant's principle; volumetric strain, and bulk modulus. Analyze thin-walled pressure vessels.
- Transform stress and strain axes in 2 dimensions using Mohr's Circle and describe the concept of principal stresses.
- Analyze deformation, shear stress and angle of twist of circular shafts.
- Analyze indeterminate shafts.
- Compute deformation, stress, and moment of inertia for beams in bending and apply the fundamental beam formula.
- Construct shear force and bending moment diagrams for transverse loading.

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

- Describe the atomic and microstructural characteristics which control the important properties of engineering materials.
- Explain the origin of the elastic modulus for each class of engineering materials (metals, ceramics, polymers and composites)
- Describe the mechanism for plastic flow in metals and plastics, and the ways in which the strength can be enhanced
- Describe elastic and plastic behaviour in simple specimens loaded in tension or compression, distinguishing between true and nominal measures of stress and strain.
- Apply fracture mechanics principles to materials.

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.

Lecture notes for the course will be available electronically on Connect.

Problem sets will be posted on Connect (on the "Quiz and Surveys" page) each **Tuesday**. They are completed on Connect and are due one week later, on the following **Tuesday at 8:00 am**. **Prelab assignments** for the physical labs will also be available on Connect. These are due on Monday at 8:00 am, regardless of which day your lab is scheduled.

In addition to the marked problems, "practice problems" will be posted to the MECH 221 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. Problem sets and pre-labs that are not submitted before the deadline will receive zero credit.

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 (available electronically on Connect)

Weekly tests, field trips, and special lectures are scheduled on Thursdays. Weekly tests are scheduled at 8:00-11:00 on Thursdays. In some weeks, a field trip will take place for some groups during Thursday morning, in which case the weekly test will be moved to the Wednesday or Friday tutorial time (8:00-9:00). 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 posted on the Connect site.

COMMUNITY SERVICE LEARNING (CSL)

As part of MECH 224, you will complete a CSL experience consisting of three elements: an off-campus CSL activity, a reflection paper, and a reflection/debriefing session. Your MECH 224 grade will be determined in part based on satisfactory completion of the three CSL elements, as outlined below.

The reflection paper will also serve as a writing exercise for MECH 226 (technical communications), and the communication elements will be assessed separately for that course.

GRADING POLICIES

Engineering Science I 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 grade for MECH 221, MATH 255, and MECH 224.

To pass Engineering Science I (MECH 221, MATH 255, and MECH 224), you must satisfy all four 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 five subjects is calculated separately – dynamics, solid mechanics, electrical circuits, ordinary differential equations, and materials.
2. **Have an overall exam grade (the combined grade of the exams for all subjects) of at least 37.5 out of 75 (50%).**
   - The overall exam grade is worth 75% of the overall course grade (see criterion 3 below). Each subject is weighted out of the total 75 as follows:
     - Dynamics: 16/75
     - Solid mechanics: 16/75
     - Electrical circuits: 16/75
     - Ordinary differential equations: 16/75
     - Materials: 11/75
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%
     - Review quiz: 5%
     - Overall exams: 75%
4. **Maintain a grade ≥50% after your overall course grade is weighted with your Community Service Learning grade. (This affects MECH 224 only.)**
   - The CSL component consists of three elements: an off-campus CSL activity (CSL_A), a reflection paper (CSL_R), and a reflection/debriefing session (CSL_D), weighted according to Table 1 below.

There are therefore 4 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 221 / MATH 255 / MECH 224) 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	(Dynamics exams grade * 16%) + (Solid Mech. exams grade * 16%) + (Electrical exams grade * 16%) + (Math exams grade * 16%) + (Materials exams grade * 11%)	≥37.5
3	Overall course grade (MECH 221 and MATH 255)	(Problem sets * 5%) + (Labs and field trips * 15%) + (Review quiz * 5%) + (Overall exams grade)	≥50
4	MECH 224 grade	(Overall course grade, if ≥50) * (0.4 + CSL_A+ CSL_R+CSL_D) Where CSL_A = 0.3 if satisfactory (0 otherwise); CSL_R = 0.15 if satisfactory (0 otherwise); and CSL_D = 0.15 if satisfactory (0 otherwise)	≥50

Students who do not meet the required result at any of the 4 levels will be assessed a final grade according to Table 2.

Final Grades for MECH 221, MATH 255, and MECH 224

Since a student may not pass Engineering Science I without satisfying all four criteria, a student's final grade for the course may not necessarily equal the calculated overall course grade (which could exceed 50% even if several 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 I due to failing in one or two subject areas (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 221 / MATH 255 / MECH 224) 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	(CSL Multiplier) * (Overall Course Grade)
1 or 2 subjects < 50%	< 50%	irrelevant	Fail	Overall Exams Grade	(CSL Multiplier) * (Overall Exams Grade)
	irrelevant	< 50%	Fail	Overall Course Grade	(CSL Multiplier) * (Overall Course Grade)
	≥ 50%	≥ 50%	Leniency (Pass 221/255; Fail 224)	Overall Grade	(CSL Multiplier) * (Subject Exams Grade of Highest Failed Subject)
3 or more subjects < 50%	irrelevant	irrelevant	Fail	Subject Exams Grade of Highest Failed Subject	(CSL Multiplier) * (Subject Exams Grade of Highest Failed Subject)

THE MECH 2 "TOP TEN" PRACTICES FOR SUCCESS

The following ten practices for success have been carefully selected based on experiences of students in previous years and our observations. We strongly encourage you to seek to develop and to apply these practices for your studies in MECH 221 and for future courses. The practices are:

1. **Transference**: applying and combining concepts in new ways you have not seen before

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

3. **Communication**: clearly expressing ideas in an orderly and logical way using written, graphical, and oral forms

4. **Solution paths**: identifying 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**: determining appropriate assumptions and clearly articulate them when formulating a solution

6. **Justification**: using engineering principles to support and justify decisions, approaches, and recommendations

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

8. **Dimensional consistency**: knowing the dimensions of common engineering parameters and being able to identify dimensionally consistent / inconsistent equations

9. **Reference quantities**: identifying real-world reference values for common physical quantities (including reference values for length, speed, mass, force, energy, and power)

10. **Significant figures**: expressing numerical quantities with an appropriate number of significant digits

Best of luck in MECH 221!