

Department of Mechanical Engineering
MECH 221 (with MECH 224 & MATH 2556)

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 2556 (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 VistaConnect under the Mech 2 site. You can access VistaConnect from your UBC student account using your campus wide login.

Lecture Notes for the course will be available electronically on Connect for some subjects are available for purchase from Staples. See Vista for details.

Problem sets will be posted on VistaConnect (on the "Quiz and Surveys" page) each Tuesday. They are completed on VistaConnect 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 VistaConnect. These additional problems will **not** be marked and you do not need to submit solutions. However, similar problems may well show up on quizzes.

VISTACONNECT 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 VistaConnect 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 VistaConnect site and available in the Mech 2 Handbook.

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. Specifically, your nominal MECH 224 grade will be determined based on your MECH 221 grade with the following factors applied:

- The off-campus CSL activity: $CSL_A = 0.3$ if satisfactory, 0 otherwise
- The reflection paper: $CSL_R = 0.15$ if satisfactory, 0 otherwise
- The reflection session: $CSL_D = 0.15$ if satisfactory, 0 otherwise

The final MECH 224 grade will then be determined according to:

$$\text{MECH 224 grade} = \text{MECH 221 grade} \times (0.4 + CSL_A + CSL_R + CSL_D)$$

The reflection paper will also serve as a writing exercise for APSC 201 (technical communications), and the communication elements will be assessed separately for that course.

GRADING SCHEME

The grading scheme of this course is approximately as follows.

Weekly problem sets (9)	5%
Labs (computer labs and physical labs, including prelabs) and field trips	15%
Review quiz	5%
Weekly tests (9)	30%
Final exams (3)	45%

With the exception above regarding CSL, a student who successfully complete all course requirements will receive the same grade for MECH 221, MECH 224, and MATH 2556. You must pass all subjects of MECH 221 (weekly tests and final exams) in order to pass the course. Please see the Mech 2 Remediation Policies posted on the [VistaConnect](#) for details about the handling of cases where one or more subjects in MECH 221 fall below 50%.

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!