MECH 329
Materials for Mechanical Design

Syllabus:

Contact Information

Professor: Mattia Bacca
Mechanical Engineering
ICICS 165
(604) 827-5076
mbacca@mech.ubc.ca
Office hours*: Thursday 3 to 4 pm
Zoom Meeting ID: 739 725 3953
Passcode: 631787

TA: Nicolas Romualdi

nicolas.romualdi@ubc.ca

Office Hours*: Wednesday, 4 to 5 pm
Zoom Meeting ID: 759 072 3698
Passcode: 376398

Iraj Hamani

idh@alumni.ubc.ca
Office Hours*: Friday, 4 to 5 pm
Zoom Meeting ID: 2365585553
Passcode: 12345

Albert Kong

kgalbert@mail.ubc.ca
Office Hours*: Thursday, 8 to 9 am
Zoom Meeting ID: 236 555 1903
Passcode: 993135

*Office hours might be adjusted to match the students' needs based on their time zone. Additional office hours will be available on demand for extenuating circumstances like different time zone, technical issues and/or logistic issues. In such cases, simply contact the TA or Instructor to schedule a meeting.

Course website: Canvas

Class Format

Lectures:	Mon	15 - 17	Online

	Wed	15 - 16	Online
Tutorials:	Tue	13 - 14	Online

Class format: Zoom lectures; Each lecture *might* include a pre-recorded video lecture to be watched by the student before the scheduled class time. The Zoom lectures will be recorded. All the video material will be posted on Kaltura and accessible via Canvas.

This course is delivered online for the first time. We thank the students in advance for their patience and cooperation. Together we will make this course exciting, fun and useful.

The students will be provided blank notes to be filled during class or by watching the pre-recorded video. After the class, the students will be provided a summary of the main content so that everyone can double-check nothing was missed. However, the summary will be insufficient to cover the content of the course, hence each student is expected to diligently attend class.

Weekly assignments will be posted on Canvas for the students to complete. The correct and diligent completion of all the assignments will count 5% toward the final grade. The assignments will also serve as practice for midterms and final. The completion of the assignments must be done by the deadline. The solution to the assignment will be posted after the deadline and solved during the Tutorials. The Tutorials will also include the solution of additional sample problems that can serve as practice for midterms and finals.

The documents provided to the students include (i) *Syllabus;* (ii) *Course description*; (iii) *Formula sheet*. The latter will be updated with new content during the course.

Pre-requisites

MECH 224, MECH 260, APSC 278; It is also recommended to attend/have attended MECH 360 (co-requisite).

Learning objectives

The student will be able to:

1. Distinguish between the <u>4 main material families</u>: *Metals; Ceramics; Polymers; Composites;* based on the <u>7 main material properties</u>: *Elastic modulus; Strength; Toughness; Fatigue life; Creep resistance; Viscosity; Corrosion resistance.*
2. Develop material selection criteria for various mechanical components based on the 7 material properties at the previous point, plus other properties such as *mass density* and *cost per unit volume*.
3. Understand the micro-mechanisms behind each one of the 7 material properties and how to use this knowledge toward *material selection* and *material design*.
4. Extract material properties from experimental observations and read material data sheets and selection charts for an informed design.

5. Design basic mechanical components after selecting an appropriate material; including considerations such as fracture criteria (*e.g.* leak before break) and other advanced concepts such as creep and corrosion resistance.
6. The student will develop a fundamental understanding of basic design of composite materials and how their properties emerge from their ingredients.

Course Assessment

Weekly assignments:	5% (Online)
Midterm 1:	20% (Online)
Midterm 2:	20% (Online)
Final Exam:	55% (Online)

Course Schedule

Based on the <u>*seven*</u> modules, the *indicative* schedule of the course is:

Week	***Module***	***Source***
1-3	**1. Elastic modulus** - *Mechanical design fundamentals*: Stress state; strain state; principal stresses; use of Mohr circles - *Elastic modulus*: Hooke's law - *Stiffness limited design*: material selection index for a tie, a beam and a panel - *Case study:* Challenger space shuttle - *Micro-mechanisms*: atomic bonding and microstructure; composite materials	Chapter 3 [1] Ch. 4-5 [2] Ch. 7 [1] Ch. 4,6 [1]
4-6	**2. Strength** - *Yield strength for ductile materials*: Residual (plastic) strain; resilience; engineering stress/strain vs true stress/strain - *Modulus of rupture for brittle materials* - *Strength limited design*: material selection index for a tie, a beam and a panel; a light/compact spring, a hinge, a seal, a blade - *Case study:* NASA super pressure balloon - *Micro-mechanisms*: yield strength for metals, dislocation pinning, grain boundary strengthening (Hall-Petch), alloying; strength of composite materials	Ch. 8 [1] Ch. 4-5 [2] Ch. 9-10 [1], Ch. 11 [2]
7-8	**3. Toughness** - *Fast fracture and toughness*: Stress intensity factor; energy release rate; fracture modes, Mode I; cleavage toughness; brittle vs ductile materials - *Toughening mechanisms*: Plastic zone; process (dissipative) zone	Ch. 13-14 [1]

	- *Fracture limited design*: defect sensitivity and transition flaw size; yield-before-break and leak-before-break - *Case study*: Liberty ship - avoiding brittle alloys	
9	**4. Fatigue life** - *Cracked components*: Paris law and micro-mechanisms of stable crack propagation - *Uncracked components*: Phenomenological law - *Fatigue in design*: avoiding stress concentration - *Case study*: The Comet Air disasters	Ch. 17-18 [1]
10	**5. Creep** - *Creep and creep fracture*: Secondary creep and phenomenological law; creep relaxation; creep damage and creep fracture - *Micro-mechanisms:* Diffusion; dislocation climbing; grain boundary sliding and diffusion - *Case study*: Jet engine turbine blades	Ch. 20-23 [1]
11	**6. Viscosity** - *Time-dependent deformation in polymers*: chain mobility; viscoelasticity and relaxation time - *Case study*: Challenger space shuttle -revisited	Ch. 23 [1]
12-13	**7. Corrosion resistance** - *Dry oxidation*: Oxidation energy; oxide layer; oxidation kinetics and diffusion; - *Case study in dry oxidation*: Protecting turbine blades - *Wet corrosion*: Voltage and wet oxidation driving force; pitting corrosion; intergranular attack; stress corrosion cracking; - *Case study in wet corrosion*: Protecting ships' hulls from corrosion	Ch. 24-27 [1]

Textbooks

[1] M.F. Ashby, D.R.H. Jones, "Engineering Materials 1: An Introduction to Properties Applications and Design", Butterworth Heinemann.

[2] M.F. Ashby, "Materials Selection in Mechanical Design", Butterworth Heinemann.