Fundamentals of Biomechanics - (334222)

Spring semester 2021

The lectures and tutorials will be given online

Lectures: Tuesdays 10:30 - 13:30

Tutorials: Sundays 14:30 – 16:30

Thursdays 10:30 – 12:30

Teaching Staff:

Instructor: Asst. Prof. Netanel Korin, Julius Silver (Biomedical Engineering) 226, korin@bm.technion.ac.il, +972-82946114.
Office Hours: by appointment.

TA: Yevgeniy Kreinin, Julius Silver (Biomedical Engineering) 327, kreinin@campus.technion.ac.il.
Office Hours: Thursdays 12:30, by appointment.

Prerequisites: Physics 1M (114071) or Physics 1P (114074)

Credits: 4 points.

Study hours per week: The course will include three hours of lecture and two hours of tutorial per week.

Course Goals and Description

This is an introductory course in principles of mechanics as applied to biological systems and medical problems. The course provides students with basic concepts and approaches for solving static, and deformation-stress analysis problems relevant to biomedical applications. Emphasis is placed on problem-posing and problem-solving skills. The first part of the course is dedicated to statics and free body diagrams. In the second part, principles in mechanics of materials are presented and their applications stress and strain analysis are discussed with emphasis on biomedical problems.

Course Objectives

- To teach students how to draw a free body diagram and solve for forces and moments
- To teach students Stress and Strain Fundamentals and Linear elasticity principles
- To teach students how to calculate stress and strain in simple structures under tension, compression, torsion, and bending
- To teach student stress and strain transformations and their application to failure analysis
- To teach students how to calculate strain energy and it application in indeterminate problems

- To teach students the physical principle of buckling and how to calculate bucking force in a simple columns

Learning Outcomes

(a) Ability to apply knowledge of biology, science and engineering.

(b) Ability to design experiments, as well as to analyze and interpret data.

(c) Ability to design a system, component, or process to meet desired needs within realistic constraints such as health and safety, manufacturability.

(d) Ability to identify and solve engineering problems.

(e) Recognition of the need for, and an ability to engage in life-long learning.

(f) Knowledge of contemporary issues.

(g) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Content/Topics

Introduction

- **Solid Mechanics**
- **Biomechanics**

Part 1: Statics

- Forces, Moments, , Resultant and equilibrium
- Free Body Diagram
- Trusses ,Truss structures, Method of Joints, Method of Sections, constrained and determinate Truss
- Distributed Forces: Centroids and Centers of Gravity
- Beams: Shear force and Bending Moment diagrams

Part 2: Mechanics of Materials

- Stress, strain, Hooke's law, elastic materials
- Stress-Strain Diagrams, Material Properties, Axial Loading and Shear Stress and Strain
- Pure Bending
- Beam Bending Analysis, Shearing stresses in Beams, Statically Indeterminate Beams
- Transformations of Stress and Strain, Mohr’s Circle, Yield Criteria
- Energy methods: Strain Energy, Work and Energy , Work and Energy Under Several Loads, Castigliano’s Theorem
- Column buckling

Assignments and Grading Procedures

Homework– 20% (weekly assignments throughout the semester)
Final Exam: 70%
Midterm:10% (Magen)

Course Schedule (Topics, assignments, Exams)

Week	Lecture topics	Lectures dated
1	Forces, Moments, Free Body Diagram (FBD)	23/03/21
2	Truss, Joints, Sections, Beams, Distributed Forces: Centroids and Centers of Gravity	06/04/21
3	Centroids by Integration, Theorems of Pappus-Guldinus , Beam Loading and Support, Beam Shear and Bendin Moment	13/04/21
4	Stress and Strain, Hooke's Law, Fatigue, Deformations Under Axial Loading, Static Indeterminacy	20/04/21
5	Thermal Stresses, Poisson's Ratio, Generalized Hooke's Law, Bulk Modulus, Shearing Strain, Saint-Venant's Principle, Stress Concentration, Torsion, Axial Shear, Shaft Deformations, Stresses in Elastic Range	27/04/21
6	Angle of Twist in Elastic Range, Statically Indeterminate Shafts	04/05/21
7	Review of Material and Midterm Exam-Simulation	11/05/21
8	Pure Bending, Strain and stress Due to Bending, Beam Section Properties	18/05/21
9	Bending of Composit beams, Shearing Stresses in Beams, Determation of the Shearing Stress in a Beam	25/05/21
10	Shearing Stresses in Thin-Walled Members, Deformation of a Beam Under Transverse Loading, Elastic Curve, Statically Indeterminate Beams, Superposition	01/06/21
11	Transformations of Stress, Mohr's Circle, Yield Criteria for Ductile Materials Under Plane Stress, Stresses in Thin-Walled Pressure Vessels	08/06/21
12	Three-Dimensional Analysis of Strain, Measurements of Strain, Strain Energy, Work and Energy	15/06/21
13	Castigliano's Theorem, Stability of Structures, Linear Viscoelasticiy	22/06/21
	Exam A- 21/07/21	
	Exam B- 08/10/21	

Week	Tutorials topics	Tutorials dates	HW
1	Forces, Moments, FBD, Truss, Joints	25/03/21 04/04/21	
2	FBD, Distributed Forces: Centroids and Centers of Gravity	08/04/21 11/04/21	1. 11/04/21
3	Distributed Forces: Centroids and Centers of Gravity	18/04/21 22/04/21	
4	Shifts of stress and uniaxial strain	25/04/21 29/04/21	2. 29/04/21
5	Trusses shifts and Static Indeterminacy	02/05/21 06/05/21	
6	Torsion, Axial Shear	09/05/21 11/05/21	3. 13/05/21
7	Pure Bending, Strain and stress Due to Bending, Beam Section Properties	23/05/21 27/05/21	4. 27/05/21
8	Bending of Composit beams, Shearing Stresses in Beams, Shearing Stresses in Thin-Walled Members.	30/05/21 03/06/21	
9	Bending of Composit beams, Shearing Stresses in Beams Determatio of the Shearing Stress in a Beam	06/06/21 10/06/21	5. 10/06/21
10	Beam Deflection	13/06/21 17/06/21	
11	Transformations of Stress, Mohr's Circle, Three-Dimensional Analysis of Strain, Measurements of Strain	20/06/21 24/06/21	6. 24/06/21
12	Work and Energy, Stability of Structures	27/06/21 01/07/21	
13	Review tutorial		

Course Requirements & Course Policies

Submissions of homework in the course are weekly, and no submission option will be given after the set date, except in exceptional cases.
The midterm is a class exam designed to simulate the final test on the material studied up to the midterm date. The participation in the exam will credit the defensive score (10%).

Accommodation for Students with special needs

Any student with a disability who may need accommodations in this class must obtain an accommodation letter from Technion International's guidance counselor, at counselor@int.technion.ac.il

Text book(s) and/or other materials

Textbook

- Meriam J.L and Kraige L.G, Engineering Mechanics: Statics and Dynamics.
- R. C. Hibbeler, Engineering Mechanics: Statics and Dynamics.
- Beer F.P, Johnston E.R Jr., Mazurek D.F, Cronwell P.J and Eisenberg E.R, Vector Mechanics for Engineers (9th edition).
- Timoshenko S., Strength of Materials, Part I & II

Online Resources

Moodle: all lecture notes / supplementary material / slides are available there.
Panopto : Recorded lectures and tutorial are available there

Academic Integrity

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

Report any violations you witness to the instructor.