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 its 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
• Column buckling
Assignments and Grading Procedures

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

Course Schedule (Topics, assignments, Exams)

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture topics</th>
<th>Lectures dated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forces, Moments, Free Body Diagram (FBD)</td>
<td>23/03/21</td>
</tr>
<tr>
<td>2</td>
<td>Truss, Joints, Sections, Beams, Distributed Forces: Centroids and Centers of Gravity</td>
<td>06/04/21</td>
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<tr>
<td>3</td>
<td>Centroids by Integration, Theorems of Pappus-Guldinus, Beam Loading and Support, Beam Shear and Bendin Moment</td>
<td>13/04/21</td>
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<tr>
<td>4</td>
<td>Stress and Strain, Hooke’s Law, Fatigue, Deformations Under Axial Loading, Static Indeterminacy</td>
<td>20/04/21</td>
</tr>
<tr>
<td>5</td>
<td>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</td>
<td>27/04/21</td>
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<tr>
<td>6</td>
<td>Angle of Twist in Elastic Range, Statically Indeterminate Shafts</td>
<td>04/05/21</td>
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<tr>
<td>7</td>
<td>Review of Material and Midterm Exam-Simulation</td>
<td>11/05/21</td>
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<tr>
<td>8</td>
<td>Pure Bending, Strain and stress Due to Bending, Beam Section Properties</td>
<td>18/05/21</td>
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<tr>
<td>9</td>
<td>Bending of Composit beams, Shearing Stresses in Beams, Determination of the Shearing Stress in a Beam</td>
<td>25/05/21</td>
</tr>
<tr>
<td>10</td>
<td>Shearing Stresses in Thin-Walled Members, Deformation of a Beam Under Transverse Loading, Elastic Curve, Statically Indeterminate Beams, Superposition</td>
<td>01/06/21</td>
</tr>
<tr>
<td>11</td>
<td>Transformations of Stress, Mohr’s Circle, Yield Criteria for Ductile Materials Under Plane Stress, Stresses in Thin-Walled Pressure Vessels</td>
<td>08/06/21</td>
</tr>
<tr>
<td>12</td>
<td>Three-Dimensional Analysis of Strain, Measurements of Strain, Strain Energy, Work and Energy</td>
<td>15/06/21</td>
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<tr>
<td>13</td>
<td>Castigliano’s Theorem, Stability of Structures, Linear Viscoelasticity</td>
<td>22/06/21</td>
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Exam A- 21/07/21
Exam B- 08/10/21
<table>
<thead>
<tr>
<th>Week</th>
<th>Tutorials topics</th>
<th>Tutorials dates</th>
<th>HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forces, Moments, FBD, Truss, Joints</td>
<td>25/03/21 04/04/21</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>FBD, Distributed Forces: Centroids and Centers of Gravity</td>
<td>08/04/21 11/04/21</td>
<td>1. 11/04/21</td>
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<tr>
<td>3</td>
<td>Distributed Forces: Centroids and Centers of Gravity</td>
<td>18/04/21 22/04/21</td>
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<tr>
<td>4</td>
<td>Shifts of stress and uniaxial strain</td>
<td>25/04/21 29/04/21</td>
<td>2. 29/04/21</td>
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<tr>
<td>5</td>
<td>Trusses shifts and Static Indeterminacy</td>
<td>02/05/21 06/05/21</td>
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<tr>
<td>6</td>
<td>Torsion, Axial Shear</td>
<td>09/05/21 11/05/21</td>
<td>3. 13/05/21</td>
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<tr>
<td>7</td>
<td>Pure Bending, Strain and stress Due to Bending, Beam Section Properties</td>
<td>23/05/21 27/05/21</td>
<td>4. 27/05/21</td>
</tr>
<tr>
<td>8</td>
<td>Bending of Composit beams, Shearing Stresses in Beams, Shearing Stresses in Thin-Walled Members.</td>
<td>30/05/21 03/06/21</td>
<td></td>
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<tr>
<td>9</td>
<td>Bending of Composit beams, Shearing Stresses in Beams Determinatio of the Shearing Stress in a Beam</td>
<td>06/06/21 10/06/21</td>
<td>5. 10/06/21</td>
</tr>
<tr>
<td>10</td>
<td>Beam Deflection</td>
<td>13/06/21 17/06/21</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Transformations of Stress, Mohr’s Circle, Three-Dimensional Analysis of Strain, Measurements of Strain</td>
<td>20/06/21 24/06/21</td>
<td>6. 24/06/21</td>
</tr>
<tr>
<td>12</td>
<td>Work and Energy, Stability of Structures</td>
<td>27/06/21 01/07/21</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Review tutorial</td>
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**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](mailto:counselor@int.technion.ac.il)
Textbook(s) and/or other materials

Textbook

- 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.