جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

# Course Syllabus: Basic Principles of Mechanics - ME 100

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| **Division** | Physical Science and Engineering Division |
| **Course Number** | ME 100 |
| **Course Title** | Basic Principles of Mechanics |
| **Academic Semester** | Fall |
| **Academic Year** | 2019/2020 |
| **Semester Start Date** | 08/25/2019 |
| **Semester End Date** | 12/10/2019 |
| **Class Schedule** (Days & Time) | 09:00 AM - 10:30 AM \| Mon Wed |

## Instructor(s)

| Name | Email | Phone | Office Location | Office Hours |
|---|---|---|---|---|
| Christos Chatzichristidis | CHRISTOS.CHATZICHRISTIDIS@KAUST.EDU.SA | +966128087427 | 4348 (Level 4), 9, Engineering Science Hall (bldg. 9) | Available to students anytime I am in my office (8:00-18:00) or email for an appointment. |

## Teaching Assistant(s)

| Name | Email |
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## Course Information

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| **Comprehensive Course Description** | 1. Solid Mechanics<br>(a) Statics of rigid bodies: Principle of transmissibility. Equivalent forces. Moment of a force about a point. External and internal forces. Free-body diagram. Reactions at supports and connections for a two-dimensional structure. Equilibrium of a rigid body in two dimensions.<br>(b) Moments of Inertia: Centroids and center of gravity. Moment of inertia of an area and a mass. Parallel axis theorem. Product of Inertia.<br>(c) Concept of axial and shearing stress: Stress components under general loading conditions. Ultimate strength of a material. Allowable load and allowable stress. Factor of safety.<br>(d) Axial loading: Normal stress and strain. Hooke's law. Modulus of elasticity. Stress-strain diagram. Elastic versus plastic behavior of a material. Repeated Loads. Fatigue. Deformation under axial loading. Poisson's ratio. Multiaxial loading. Generalized Hooke's law. Shearing strain. Modulus of rigidity.<br>(e) Torsion of circular shafts: Elastic torsion formulas. Angle of twist.<br>(f) Bending: Symmetric member in pure bending: stress, strain and deformation. Neutral surface and neutral axis. Elastic flexural formulas. Curvature. Eccentric axial loading applied in a plane of symmetry. Deformation of a beam under transverse loading. Elastic curve.<br>(g) Analysis and design of beams for bending: Shear and bending moments diagrams. Design of prismatic beams for bending.<br>(h) Transformation of plane stress: Principal stresses. Mohr's circle. Yield criteria for ductile materials under plane stress. Fracture criteria for brittle materials under plane stress.<br>(i) Kinematics of particles: Rectilinear motion of a particle. Curvilinear motion of a particle.<br>(j) Kinetics of particles: Newton's second law of motion. Linear momentum of a particle. Angular momentum of a particle.<br>(k) Kinetics of particles: energy and momentum methods: Work of a force. Kinetic energy of a particle. Principle of work and energy. Potential energy. Conservative forces. Conservation of energy. Principle of impulse and momentum.<br>(l) Planar kinematics of rigid bodies: Translation. Rotation about a fixed axis. General plane motion. Absolute and relative velocity. Absolute and relative acceleration.<br>(m) Plane kinetics of rigid bodies: Angular momentum of a rigid body in plane motion. Equations of motion of a rigid body. Systems of rigid bodies.<br>(n) Plane kinetics of rigid bodies. Principle of work and energy for a rigid body. Kinetic energy of a rigid body in plane motion. Systems of rigid bodies. Conservation of energy. Principle of impulse and momentum for a rigid body in plane motion. Conservation of angular momentum. System of rigid bodies.<br>2. Fluid Mechanics<br>(a) Fluid kinematics: Descriptions of a fluid field: Lagrangian, Eulerian and augmented Langrangian-Eulerian. The material or substantial derivative. Streamlines, trajectories and streaklines.<br>(b) Fluid forces: Body forces. Surface forces. The concept of pressure.<br>(c) Fluid statics: The basic equation in fluid statics. Hydrostatics.<br>(d) Integral conservation principles. Mass conservation. Linear momentum equation. Angular momentum equation. Total energy conservation. The Bernoulli equation. Initial and boundary conditions.<br>(e) Dimensional analysis: Dimensional homogeneity. Buckingham's theorem. Reynold's number. Similarity. Dimensionless equations.<br>(f) Internal incompressible viscous flow: Fully developed laminar flow. Flow in pipes and channels. Shear stress distribution. Turbulent velocity profiles. Moody chart. Head loss.<br>(g) Compressible flow: Basic equations for one-dimensional compressive flow. |
| **Course Description from Program Guide** | |
| **Goals and Objectives** | The goal of the course is to organize and review the fundamentals of static and dynamics of rigid bodies, mechanics of materials and fluid mechanics. |
| **Required Knowledge** | Undergraduate Calculus. |
| **Reference Texts** | 1. Mechanics of Materials, Ferdinand Beer, Jr., E. Russell Johnston, John DeWolf, David Mazurek, McGraw-Hill Science, 2011 (any other edition is ok).<br>2. Vector Mechanics for Engineers: Statics and Dynamics, Ferdinand Beer, Jr., E. Russell Johnston, David Mazurek, McGraw-Hill Science, 2012 (any other edition is ok).<br>3. Fluid Mechanics Fundamentals and Applications, by Yunus Cengel and John Cimbala, McGraw-Hill Education; 3rd edition (January 30, 2013). |
| **Method of evaluation** | **45.00**% - Final exam<br>**15.00**% - Quiz(zes)<br>**20.00**% - Exam 2<br>**20.00**% - Exam 1 |

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| **Nature of the assignments** | There are three components to the final grade: 3 quizzes, 2 tests, and a final exam. The contribution of each component to the course grade is as follows:<br>1. Quizzes (x3) -- 5% each<br>2. Tests (x2) -- 20% each<br>3. Final Exam -- 45%<br>The three quizzes have a duration of 30 minutes and will be held at the beginning of the following lectures: Sept 18 (Wed); Oct 21 (Mon); Nov 18 (Mon).<br>The two 80-minute tests will be held during lecture time on the following Monday lectures: October, 7 and November, 25.<br>The final exam is on Wednesday, December, 4, during lecture.<br>Problem sets will be given as ungraded homework. The quizzes will be based on these sets.<br>To pass the course, the final grade should be at least 70%. The grading system is S(Satisfactory)/U(Unsatisfactory). |
| **Course Policies** | If a student is absent more than 15% of the classes, he/she will be disqualified for the final exam.<br>The students are required to attend all lectures and to take notes. The students will read the corresponding material in advance, and the instructor will present a summary of the topics and work out appropriate examples.<br>Students that do not show up for a quiz, a test or the exam should expect a zero in that assessment.<br>All quizzes, tests and final exam are closed-book and closed-notes. The student may use one A4 sheet with formulae and a calculator. |
| **Additional Information** | |

## Tentative Course Schedule

*(Time, topic/emphasis & resources)*

| Week | Lectures | Topic |
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| 1 | Mon 08/26/2019<br>Wed 08/28/2019 | Course and lecturer introduction.<br>Statics. |
| 2 | Mon 09/02/2019<br>Wed 09/04/2019 | Centroids. Moments and products of inertia.<br>Concept of axial and shearing stress. |
| 3 | Mon 09/09/2019<br>Wed 09/11/2019 | Axial loading.<br>Torsion of circular shafts. |
| 4 | Mon 09/16/2019<br>Wed 09/18/2019 | Bending. Analysis and design of beams for bending.<br>Quiz 1. Transformation of plane stress. |
| 5 | Mon 09/23/2019<br>Wed 09/25/2019 | **Saudi National Day - No Class**<br>Kinematics of particles: Rectlinear and Curvlinear motion of a particle. |
| 6 | Mon 09/30/2019<br>Wed 10/02/2019 | Kinetics of particles I: Newton's second law.<br>Kinetics of particles II: energy and momentum methods |
| 7 | Mon 10/07/2019<br>Wed 10/09/2019 | Test 1<br>Planar kinematics of rigid bodies: Translation, rotation about a fixed axis, absolute and relative velocity and acceleration. |
| 8 | Mon 10/14/2019<br>Wed 10/16/2019 | Planar kinetics of rigid bodies I: Equations of motion of a rigid body.<br>Planar kinetics of rigid bodies II: energy and moment methods |
| 9 | Mon 10/21/2019<br>Wed 10/23/2019 | Quiz 2. Fluid kinematics: Descriptions of a fluid field: Lagrangian, Eulerian and aug-mented Langrangian-Eulerian.<br>Fluid forces. Fluid statics. |
| 10 | Mon 10/28/2019<br>Wed 10/30/2019 | **Mid-term break - No Class**<br>Integral conservation principles I: Mass conservation, linear and angular momentum equations. |
| 11 | Mon 11/04/2019<br>Wed 11/06/2019 | Integral conservation principles II: Total Energy Conservation<br>Integral conservation principles III: The Bernoulli equation, initial and boundary conditions. |
| 12 | Mon 11/11/2019<br>Wed 11/13/2019 | Dimensional analysis I: Dimensional homogeneity, Buckingham’s  theorem<br>Dimensional analysis II: Reynold’s number, similarity, and dimensional equations. |
| 13 | Mon 11/18/2019<br>Wed 11/20/2019 | Quiz 3. Internal incompressible viscous flow I: Fully developed laminar flow<br>Internal incompressible viscous flow II: Flow in pipes and channels. Shear stress distribution. Turbulent velocity profiles. |
| 14 | Mon 11/25/2019<br>Wed 11/27/2019 | Test 2<br>Basic equations for one-dimensional compressive flow. |
| 15 | Mon 12/02/2019<br>Wed 12/04/2019 | Review.<br>Final Exam |
| 16 | Mon 12/09/2019 | |

### Note

The instructor reserves the right to make changes to this syllabus as necessary.