NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF ENVIRONMENTAL ENGINEERING
SANITARY ENGINEERING PROGRAM

EC115 – RIGID BODY MECHANICS

I. GENERAL INFORMATION

CODE	**:**	EC115 Rigid Body Mechanics
SEMESTER	**:**	4
CREDITS	**:**	4
HOURS PER WEEK	**:**	5 (Theory, Practice)
PREREQUISITES	**:**	AA234 Physics II, AA221 Mathematics II
CONDITION	**:**	Compulsory

II. COURSE DESCRIPTION

This course introduces the main principles of Mechanics and its applications. Its general objective is the grasp of concepts such as force, torque, force system reduction, equilibrium applied to iso-static structures (lattices or reinforcements, casing and others), distributed forces. Centers of gravity. Moments and products of inertia in flat areas. Beams and its internal actions due to loads, axial and shear forces diagram, bending moment. Cables and friction.

III. COURSE OUTCOMES

1. Identify load systems interacting on a particle and a rigid body.
2. Reduce any load system to the simplest resultant acting on a particle or rigid body.
3. Determine the geometric and resistance characteristics of the structural element.
4. Apply methods for the calculation of internal forces for framework, frame and cable elements.
5. Make diagrams of axial force, shear force and bending moment in a beam statically determined.
6. Handle main principles of statics and apply them in the solution to problems of isostatic systems equilibrium.
7. Create models representing the dynamics of moving particles and bodies (longitudinal and rotational motion).

IV. LEARNING UNITS

1. FORCE AND REDUCTION OF FORCE SYSTEMS / 18 HOURS

General comments about Forces / Characteristics. Moment of a force regarding a point and an axis / pair of Forces / translation of a force / Equivalence of a system of forces / resultant of force systems: collinear, concurrent, parallel, coplanar and spatial / Torsion characteristics / Force systems distributed on a line / Force systems distributed on a surface (center of pressure) and a volume (Center of gravity).

2. EQUILIBRIUM OF A PARTICLE AND A RIGID BODY / 24 HOURS

Equilibrium / Reactions associated to support or end types / Equilibrium principles for a particle in the plane and in the space / Equilibrium principles in the plane and in the space for a rigid body / free body diagram / Reinforcements / Main elements / Shaping / reinforcement analysis / Node equilibrium method / Section method / Casing and frame / Force analysis in casings / Simple mechanisms.

3. CENTROIDS. INERTIA MOMENTS AND PRODUCTS

Centroids of lines and areas and compound and simple volumes / Pappus' Theorems / Center of gravity / Inertia moments and products of inertia in flat areas / Inertia moments and products in compound areas / Radiuses of gyration / Parallel Axes Theorem (Steiner) / Inertia moments and products regarding inclines axes / Main inertia axes and moments / Determination of maximum and minimum inertia products axes / Mohr's circumference.

4. BEAMS AND INTERNAL ACTIONS IN THEM. CABLES. FRICTION

Beams / classification according to the type of support / Definition of the internal actions in a section: Axial stress, shear stress and bending moment / Diagram of variation of these internal actions throughout the beam axis, under different load conditions / Relationships against load intensity, shear stress and bending moment / calculation of the maximum and minimum of these internal actions / flexible cables: cables with concentrated loads / Cables with distributed loads: parabolic and overhead power cables / Maximum and minimum cable stress / Cable length / friction. Types of friction: dynamic and static / Friction coefficient / Angle of repose / Roll angle.

5. PARTICLE KINEMATICS. RELATIVE MOTION

Framework of reference. Position. Trajectory parametrical equations. Velocity and acceleration. Velocity and acceleration in Cartesian coordinate system. Intrinsic components of acceleration. Applications. Particle movement in other coordinate systems. Coordinate systems that revolve with respect to a fixed coordinate system. General equation for the particle movement with respect to the moving coordinate system. Applications.

6. KINEMATICS OF A RIGID BODY

General equation for the movement of a rigid body. Translational motion. Rotation movement around a fixed axis. Main properties of the rigid body movement. Instantaneous axis of rotation and slipping. Movement in one plane of a rigid body. Instantaneous center of rotation. Rigid body movement with respect to a moving coordinate system. Rigid body movement with a fixed point. Euler angles. Euler velocities. General movement of a solid. Applications.

7. WORK AND ENERGY

Differential equations for movement in various coordinate systems. Impulse and momentum. Conservation of momentum. Momentum and impulse theorem. Work and energy. Work-energy theorem and kinetic energy. Fields of conservative forces. Potential energy. Mechanical energy conservation. Center of mass movement. Total kinetic energy of a system of particles. Work and energy equation. Impulse and momentum. Angular momentum. Application.

V. METHODOLOGY

An active method in the learning-teaching process is used in this course. Students participate in this method every class either individually or in work groups. The instructor exposes and gives examples to complement the students' activity, using the available audiovisual aids and afterward the virtual campus. The classroom work is complemented with quizzes and homework uploaded to the virtual that students do periodically and/or weekly.

VI. EVALUATION FORMULA

The average grade PF is calculated as follows:

$$\mathbf{PF = 0.25\ EP + 0.25\ PP + 0.50\ EF}$$

EP: Mid-Term Exam EF: Final Exam
PP: Average of six quizzes

VIII. BIBLIOGRAPHY

1. **HIBBELER, R. C.**
   Mechanical Engineering: Statics
   Prentice Hall Editorial, 10th Edition, 2008
2. **BEER, FERDINAND AND JOHNSTON JR. RUSSELL**
   Vectorial Mechanics for Engineering
   Mc. Graw Hill Editorial, 7th Edition, 2007
3. **PYTEL, ANDREW AND JAAN, KIUSALAS**
   Mechanical Engineering
   International Thomson Edition, 2nd Edition, 2000