NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING

MECHATRONICS ENGINEERING PROGRAM

MT516 MULTIBODY SYSTEMS DYNAMICS

I. GENERAL INFORMATION

CODE	**:**	MT-516 Multibody Systems Dynamics
SEMESTER	**:**	6
CREDITS	**:**	3
HOURS PER WEEK	**:**	4 (Theory–Practice)
PREREQUISITES	**:**	MB-155 Differential Equations MC-338 Dynamics
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Applied Engineering
INSTRUCTOR	**:**	José Machuca Mines, Iván A. Calle Flores
INSTRUCTOR E-MAIL	**:**	jomachmin@gmail.com, icallef@uni.pe

II. COURSE DESCRIPTION

The course prepares to the students in applying the concepts, analysis, implementation and techniques of differential equations (physical development) describing the motion in the plane and in the space of systems formed by multiple elements (bodies). The kinematic formulation is obtained by applying the Denavit-Hartenberg representation and dynamics are derived from physical laws, such as Newtonian mechanics, Lagrangian mechanics and other, and the use of specialized software is made. The physical system equations describe the dynamic behavior over time and is used for the analysis, synthesis and simulation of motion in computer, perform the evaluation of structural system design, design servomechanisms that drive each joint and the control of real-time motion of the system.

III. COURSE OUTCOMES

1. Formula, analyzes and describes the kinematic behavior of multibody systems by mathematical equations.
2. Formula, analyzes and describes the dynamic behavior of multibody systems by differential equations.
3. Perform an analysis and interpretation of the dynamic behavior of multibody systems.
4. Apply the dynamic concepts for the design of s multijoined patial mechanical structures.
5. Explain and determines the movement of multibody systems over time using specific software.
6. Make the simulation of the dynamic behavior of multibody systems by computer.

IV. LEARNING UNITS

1. ROTATION MATRIX

Coordinate systems. Rotation matrices with respect to the principal axes of a Cartesian coordinate system. Composite matrices rotation. Matrices rotation about an arbitrary axis. Rotation matrices using Euler angles. Rotation and translation of matrices of 4x4 dimension. Homogeneous transformation matrices. Geometric interpretation of rotation matrices.

2. TRANSMISSION ELEMENTS OF MOVEMENT AND TYPES OF JOINT

Gears. Gear types. Zippers, pulleys, belts, screws on endless, Harmonic drive's. Joints. Types of joints. Degrees of freedom.

3. KINEMATICS OF MULTIBODY SYSTEMS

Types of kinematic variables. Joint variables and Cartesian variables. Direct and inverse kinematics position. Representation of Denavit-Hartenberg (D-H). D-H rules and algorithms. D-H parameters. Direct kinematics position from homogeneous transformation matrices. Kinematics reverse position. Position, velocity and acceleration joint. Cartesian linear speed and acceleration. Cartesian Speed and Cartesian angular acceleration. Jacobian matrices. Points of singularity. Differential kinematic modeling. Kinematics with restrictions. Kinematic applications for mechanical structures of serial chain and kinematic closed chain. Branched and complex chains.

4. **VECTORIAL KINEMATICS**

   Symmetric matrices biased. Kinematic equations of position, velocity and linear acceleration Cartesians. Kinematic equations of position, velocity and angular acceleration Cartesians. Application of vector equations.

5. **BYNAMIC FORMULATION IN THE PLANE**

   Free body diagrams. Dynamic equations of rigid systems in the plane using the Newton’s method. Dynamic equations of rigid systems in the plane using the D'Alambert’s method. Physical applications in both methods.

6. **SPATIAL DYNAMIC FORMULATION OF SIMPLE SYSTEMS**

   Lagrangian formulation. Total kinetic energy. Total potential energy. Spatial dynamic of multibody simple systems. Friction equations. Applications. Dynamic formulation by Newton's method. Dynamic with restrictions. Dynamic application for serial structure systems.

7. **DYNAMIC FORMULATION OF COMPLEX SYSTEMS**

   Type I Lagrangian formulation. Total kinetic energy. Total potential energy. Spatial dynamics of multibody simple systems. Dynamic application to systems of complex structure.

V. METHODOLOGY

The course develops theory and practical sessions aimed at the computer lab. In the theory sessions, the instructor presents the concepts, analysis and applications. In the practical sessions, various problems are solved and the solution is analyzed. In all sessions, the active participation of students is encouraged.

VI. EVALUATION FORMULA

The Average Grade PF is calculated as follow:

PF = (EP + 2EF + PP) /4

EP: Mid-Term Exam
EF: Final Exam
PP: Average of practices

VII. BIBLIOGRAPHY

1. **SHABANA, AHMED A.**
   Computational Dynamics. Second Edition. 2005.
2. **WELLS, DARE A.**
   Theory and Problems of Lagrange Dynamics. McGraw-Hill. 1992.
3. **SPONG, MARK W. AND VIDYASAGAR, M.**
   Robot Dynamics and Control. Editorial JOHN WILEY & SONS. 2005.