NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
NAVAL ENGINEERING PROGRAM

MV436 – DRAG AND PROPULSION

I. GENERAL INFORMATION

CODE	**:**	MV436 Drag and Propulsion
SEMESTER	**:**	7
CREDITS	**:**	4
HOURS PER WEEK	**:**	6 (Theory–Practice)
PREREQUISITES	**:**	MV435 Vessel Hydrodynamics
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Naval Engineering

II. COURSE DESCRIPTION

The course prepares students for analyzing the drag and propulsion forces acting on a running vessel. The total motion resistance and its components are analyzed, as well as its experimental evaluation. The geometric and dynamic aspects of propellers are analyzed for creating force leading to smooth and controllable motion. Propeller constructive issues, cavitation phenomena, performance and efficiency are also analyzed.

III. COURSE OUTCOMES

At the end of the course, students:

1. Analyze the drag and running resistance in different navigability conditions.
2. Analyze the different types of resistance including viscous resistance and wave formation resistance.
3. Analyze propulsion forces and power, as well as propulsion efficiency.
4. Analyze different types of propellers, their dynamic behavior and efficiency.
5. Analyze the geometry of propellers, their hydrodynamic features and constructive aspects.
6. Evaluate propeller-hull performance, and analyze propeller cavitation phenomena.

IV. LEARNING UNITS

1. **TOTAL RESISTANCE AND COMPONENTS**
   Introduction / Dragging / Test of variables related to resistance / Division of resistance into components / Dimensional analysis / Fraud Similarity Law / Total resistance and its components / Application problems.
2. **VISCOUS RESISTANCE**
   Introduction / Friction resistance / Type of flows / Experimental methods for calculation of friction in flat plates / Theoretical-experimental method for calculating friction on flat plates / Smooth flat plate / Application problems.
3. **WAVES FORMATION RESISTANCE**
   Introduction / Waves of deep water / Systems of waves generated by a ship / Formulation of resistance generated by wave formation / Influence of the Froude number in the resistance by waves formation.
4. **OTHER COMPONENTS OF RESISTANCE**
   Roughness / Influence of the surface roughness on drag / Influence of shallow water on resistance / Wind resistance / Resistance of appendices / Influence of shape on resistance.
5. **HYDRODYNAMICS TESTING CHANNEL AND CORRELATION METHODS**
   Hydrodynamic testing channels / Models / Trailer tests / Experimental calculation of drag forces / Requirements for experimental models / Approximate methods for calculation of drag / Calculation of drag by systematic series.

6. **NAVAL PROPELLERS**
   General definitions of propeller / Naval propulsion system / Active propulsion / Reactive propulsion / Theory of the ideal propeller / Thrust / Angular speed of propeller disc / Definition of power and efficiency / Power estimation / Efficiency of propellers / Fundamentals of wing theory.
7. **GEOMETRY AND PROPELLERS CONSTRUCTION**
   Geometric relations / Propeller graphic representation / Helical surfaces / Hydrodynamic features of propellers / Operation of propeller / Rotation and sections of propellers / Forces acting on the helix board / Values of the force T and momentum Q in special cases / Graphics of the hydrodynamic characteristics of propellers / Influence of geometric parameters of propeller on its hydrodynamic characteristics.
8. **EXPERIMENTAL ANALYSIS OF PROPELLER PERFORMANCE**
   Propeller performance and overall efficiency / Components of total efficiency of propulsion / Required data for propeller design and selection / Systematic tests with models in testing tanks / Similarities between the propeller and its model / Testing methods.
9. **RELATIONSHIP PROPELLER-HULL OF THE SHIP**
   Estela theory / Propeller-hull performance / Suction coefficient / Relative rotary performance / Performance of the hull / Propulsive performance / Propulsion coefficient.
10. **PROPELLER CAVITATION**
    Physical nature of cavitation / Cavitation criteria / Propeller cavitation modes / Stages of propellers cavitation / Negative results of cavitation and how to avoid it.
11. **PROPELLERS PROJECT FORMULATION**
    Selection of geometric characteristics / Number of propellers and direction of motion / Selection of propellers / Calculation of propellers parameters / Analysis of the mechanic structure of shovels / Performance of vessel propulsion system / Propulsive features of the ship / Propellers of controllable step / Trailer testing / Design of propellers for attaining maximum speed for a given engine / Design of propeller for the maximum traction with fixed speed of a given engine.

V. PRACTICAL WORK

Practice 1: Types of resistance
Practice 2: Hydrodynamics and correlation
Practice 3: Propellers testing
Practice 4: Propellers design and selection

VI. METHODOLOGY

The course takes place in theory and practice sessions. In theory sessions, faculty presents the concepts, principles and methods. In practice sessions, students analyze and solve diverse problems related to drag and propulsion of different types of vessel. At the end of the course, students present and defend a final report. Student active participation is promoted throughout the course.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + PP) / 3

EP: Mid-term Exam EF: Final Exam
PP: Average of Practical Works

VIII. BIBLIOGRAPHY

1. SNAME
   Principles of Naval Architecture, Volume II.
2. ALAEZ ZAZURCA.
   Introduction to the Theory of Propellers Operation. Polytechnic University of Madrid, Spain, 2010.