FACULTY OF **ENGINEERING**

DEGREE COURSE: **INDUSTRIAL ENGINEERING BS**

**SUBJECT**: FUNDAMENTALS OF FLUID DYNAMICS

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## OBJECTIVES

The course is aimed at:

1) providing the general framework of the phenomena of statics and dynamics of fluids and models to represent them.
2) The main goal consists in the acquisition of a thorough knowledge of the fluid streams, allowing the identification of the fundamental aspects and most critical and, consequently, to consciously choose, from time to time, the level of modeling necessary and sufficient to describe them in appropriately"

## CONTENTS

Introductory concepts

- Intensive, extensive and specific properties of matter; Continuum hypothesis, density and specific weight, compressibility coefficients; Equation of state of an ideal gas, Energy and specific heat.
- dynamic and kinematic viscosity, Newtonian fluids and viscosity, surface tension and capillary effects.

Static

- The absolute and relative pressure, the pressure isotropy, the Stevino's law, hydrostatic loads
- Pascal’s law, immiscible liquids, fluids of variable density, pressure gauge and barometer
- Calculation of hydrostatic thrust, thrust on flat surfaces, center of pressure and the line of action.
- Thrust on curved surfaces and buoyancy forces.

Kinematics

- Eulerian and Lagrangian description, substantial derivative, total acceleration
- Trajectories, lines of smoke and streamlines, streamtube, material volume, definition of vorticity
- Strain rate tensor, strain rate and linear variation of volume
- Velocity and angular deformation
- Reynolds transport theorem (quasi one-dimensional version)
- Generalization of Reynolds theorem

Conservation equations in integral and differential form
- Conservation of mass
- Stream function and its physical interpretation
- Conservation of momentum
- Stress Tensor
- Newtonian fluids, Navier-Stokes equations
- Couette's Flow

Bernoulli's theorem and conservation of energy
- Bernoulli's theorem, Pitot tube
- Derivation of the Bernoulli theorem alternative
- Conservation of energy in integral form

Pressurized Streams
- Hagen-Poiseulle flow
- Pressure Losses, laminar and turbulent
- Darcy and Nikuradse equations
- Formulas for commercial tubes and Moody's graph
- Pressure drop for non-circular sections

Approximate solutions of irrotational and rotational flows
- Dimensionless form of the Navier Stokes equations
- Velocity potential
- Vorticity and circulation, outline of the theorem of Helmholtz
- Notes on Kelvin's theorem

The boundary layer
- The laminar boundary layer equations
- Blasius solution for the laminar boundary layer equations
- Displacment Thickness and Momentum Thickness
- Integral solution of the boundary layer equations
- Detachment of the boundary layer
- Notes on turbulent boundary layer

Similarity theory
- Buckingham Theorem, dimensionless groups and the technique of repeated variables

# LEARNING OUTCOMES

At the end of the course, students will have:
- acquired the basic tools of fluid dynamics,
- the ability to formulate mathematical models and achieve solutions to simple problems of partial differential equations, with particular reference to those about the incompressible fluid dynamics
- be able to solve in a simplified manner the most common problems in engineering practice related to the statics and dynamics of fluids

# ASSESSMENT

Written exam: multiple choice and open questions

## RECOMMENDED TEXTBOOKS

*Fluid Mechanics: Fundamantals and Applications*; Yunus A. Cengel ,John Cimbala; Mc Graw Hill Companies