2021-2022	Mechanical Engineering	Year 3 - Sem. 5
MECA304	Fluid Mechanics in ME	Mandatory
ECTS: **4**	*Coordinator:* Pr Gilbert Accary	*Language:* English/French
Total hours: **54 h**	*Lectures:* Pr Gilbert Accary, Dr Hanna Nakhoul, Pr Rafic Younes	

Description:

Throughout this course, the student is made aware of some fundamental aspects of fluid mechanics. The course covers the following subjects: Physical properties of Fluids; Bernoulli equation, energy line and hydraulic grade line; Fluid kinematics, streamlines; Reynolds transport theorem, conservation of mass, of linear momentum, and of energy; Differential analysis of fluid flow, continuity and linear momentum; Navier-Stokes equation for viscous, incompressible fluid flows; Flow over immersed bodies, lift and drag coefficients; Boundary layer concept, transition from laminar to turbulent flow. This timely consideration of elementary fluid dynamics will increase student enthusiasm for the more advanced fluid mechanics courses that follow.

Learning outcomes:

- Recognize the various types of fluid flow problems encountered in practice,
- Have a working knowledge of the basic properties of fluids and their consequences in fluid flow,
- Distinguish between various types of flow visualizations and methods of plotting the characteristics of a fluid flow,
- Understand the many ways that fluids move and deform,
- Apply the conservation of mass equation in a flow system,
- Understand the use and limitations of the Bernoulli equation, and apply it to solve a variety of fluid flow problems,
- Work with the energy equation expressed in terms of heads, and use it to determine hydraulic turbine power output and pumping power requirements,
- Identify the various kinds of forces and moments acting on a control volume and use control volume analysis to determine the forces associated with fluid flow,
- Use control volume analysis to determine the moments caused by fluid flow and the torque transmitted,
- Understand how the differential equation of conservation of mass and the differential linear momentum equation are derived and applied,
- Learn to simplify Navier-Stokes equations and obtain analytical solutions of the equations of motion for simple flow fields,
- Understand the boundary layer concept and main properties,
- Calculate the drag force associated with flow over common geometries, and understand the effects of flow regime on the drag coefficients associated with flow over cylinders and spheres,
- Understand the fundamentals of flow over airfoils, and calculate the drag and lift forces acting on airfoils.

Content:

- Introduction to fluid mechanics, classification of fluid flows, basic concepts: no-slip condition, flow rate, velocity profile, average velocity, pressure at a point, variation of pressure with depth.
- Physical properties of fluids: density and specific gravity, vapor pressure and cavitation, energy and specific heats, compressibility and speed of sound, viscosity, surface tension and capillary effect.
- Fluid kinematics: Lagrangian and Eulerian descriptions (acceleration field, material derivative), flow patterns and flow visualization (streamlines, pathlines, streaklines …), motion and deformation of fluid elements, vorticity and rotationality, Reynolds transport theorem.
- Bernoulli and energy equations: conservation of mass, mechanical energy and efficiency, the Bernoulli equation (derivation, limitations on the use of the Bernoulli equation, hydraulic grade line and energy grade line, applications of the Bernoulli equation), general energy equation, energy analysis of steady flows.
- Momentum analysis of fluid systems: choosing a control volume, forces acting on a control volume, the linear momentum equation, review of rotational motion and momentum, the angular momentum equation.
- Differential analysis of fluid flow: conservation of mass - the continuity equation, the differential linear momentum equation - Cauchy's equations, the Navier–Stokes equations, approximate solutions of the Navier–Stokes equations, the boundary layer

concept (the boundary layer equations, boundary layer thickness, transition to turbulence).

- Flow over immersed bodies: types of external flows, drag and lift, friction and pressure drag, drag coefficients of common geometries, parallel flow over flat plates, flow over cylinders and spheres, airfoils lift and drag.

References:

- Yunus. A. Cengel, John M. Cimbala. Fluid Mechanics: Fundamentals and Applications. 3rd edition, McGraw Hill (Textbook).
- Bruce R. Munson, Donald F. Young, Theodore H. Okiishi. Fundamentals of Fluid Mechanics. John Wiley & Sons.
- Frank M. White. Fluid Mechanics. McGraw-Hill Series in Mechanical Engineering.

Evaluation Method:

Assessment in the following areas will be converted to points, to compute your final grade in this course:

- Mid-Term
- Final Exam
- Home Works

Description :

A travers ce cours, l'étudiant est sensibilisé à différents aspects fondamentaux de la mécanique des fluides. Le cours couvre les sujets suivants : Propriétés physiques des fluides ; Équation de Bernoulli, ligne d'énergie et ligne piézométrique ; Cinématique des fluides, lignes de courant ; théorème de transport de Reynolds, conservation de masse, de quantité de mouvement et d'énergie ; Analyse différentielle d'écoulement du fluide, équations de continuité et de quantité de mouvement ; Équation de Navier-Stokes pour les écoulements incompressibles de fluides visqueux ; Écoulement autour de corps immergés, coefficients de portance et de traînée ; Concept de couche limite, transition à la turbulence. Ce cours élémentaire prépare les étudiants et augmente leur enthousiasme pour des cours plus avancés en mécanique des fluides qui viendront par la suite.