**University of Management and Technology**

**Course Outline**

Course code: MTH-631

Course title: Advanced Fluid Dynamics

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| Program | PhD/MS Mathematics |
| Credit Hours | 03 |
| Duration | One Semester |
| Prerequisites | Calculus and Analytical Geometry includes limits, continuity, integration and differentiation. Ordinary differential equations. Vector analysis Basic Physics includes mechanics & heat transfer |
| Resource Person | Dr. Muhammad Imran Asjad |
| Counseling Timing  (Room# ) |  |
| Contact | imran.asjad@umt.edu.pk |

**Chairman/Director signature………………………………….**

**Dean’s signature…………………………… Date………………………………………….**

**Learning Objective:**

Upon successful completion of this course, you will:

1. At a conceptual level:

* The main purpose of this course is to develop the understanding of the fundamental principles
* Ability to solve, quickly and efficiently, a variety of real fluid mechanics problems from basic principles.
* Understand the main concepts, the basic principles, methods and modeling approximations that form the basis of fluid mechanics.
* Analyzing various fluid flow phenomenon through pipes/ducts, plates and different geometries which are familiar in many fluid engineering applications.

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1. At a more technical level:

* Obtaining a solid understanding of the fundamentals of Fluid Mechanics.
* Developing concepts and physical intuitions of fluids at rest and in motions
* Formulating basic equations and laws of fluids in rest and in motion.
* Modeling various fluid flow problems mathematically and solve them using the mathematical techniques.

**Learning Methodology:**

Learning methodology would consists of the following ingredients:

1. Cover basic principles of fluid dynamics.
2. Comfortable with applying integral transforms to partial differential equations to obtained exact solutions.
3. Compare and critical analysis of Newtonian and non-Newtonian fluids.
4. Able to read, understand and explore research articles.
5. Able to write at least term paper.

**Grade Evaluation Criteria**

Following is the criteria for the distribution of marks to evaluate final grade in a semester.

**Marks Evaluation Marks in percentage**

Quizzes 10%

Assignments 10%

Mid Term 20%

Attendance & Class Participation 5%

Term Project 10%

Presentations 10%

Final exam 35%

Total 100%

**Recommended/Reference Books:**

1. Munson, Young and Okiishi's, “Fundamentals of Fluid Mechanics”, 8th Edition, John Wiley & Sons.
2. Robert W Fox & Alant McDonald “Introduction to Fluid Mechanics”   
   John Wiley & Sons.
3. Frank M. White, “Fluid Mechanics”   
   McGraw-Hill.
4. Nazeer Ahmed, “Fluid Mechanics”

Engineering Press Inc. San Jose, California.

1. Yunus A. Cengel, John M. Cimbala “Fluid Mechanics Fundamentals and Applications” , MCGRAW-HILL series in Mechanical Engineering.
2. G.K. Batchelor “An introduction to fluid dynamics” Cambridge University Press.
3. L.D. Landau & E.M. LIfshitz “Fluid Mechanics’’ Pergmon Press

**Calendar of Course contents to be covered during semester**

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| **Week** | **Course Contents** | **Reference Chapter(s)** |
| 1 | A Brief Historical Introduction to fluid mechanics, Definition of fluid, Difference between a solid and a fluid, Viscosity. |  |
| 2 | Some Basic definitions, System and environment, Control volume and Control surface, Dimensions & Units. Differential versus integral approach, Description of method, Deformation in a fluid element. |  |
| 3 | A brief introduction of Newtonian and non-Newtonian fluids, Newton's law of viscosity, Shear Stress and Shear strain relation. Surface Tension, Capillarity, Fluid Kinematics, Field, Lagrange's and Euler's form of field representation, Velocity field, Acceleration |  |
| 4 | Types of flow, Uniform and non-uniform flow, rotational and irrotational flow. Steady and unsteady flow, laminar and turbulent flow, one-, two- and three-dimensional flow, Path lines, Streak lines, time lines, stream lines and stream tubes |  |
| 5 | Equations of stream lines and stream tubes. Stream function and flow rate, Equations of Path lines and Streak lines. |  |
| 6 | Fluid Statics Static Equilibrium, Pressure, Gravity, Basic Hydrostatic Equations. Law of conservation of mass, Continuity equation, Continuity equation for compressible and incompressible fluid. |  |
| 7 | Velocity potential and its relationship with stream function, Fluid rotation, fluid deformation. |  |
| 8 | Motion of incompressible in viscid flow, Bernoulli equation, Euler equation of motion, General analysis of fluid motion. |  |
| 9 | Forces acting on fluid particles, Constitutive Equations, Law of conservation of momentum |  |

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| 10 | Navier-Stokes equations in Cartesian and cylindrical Coordinates, Exact solutions of Navier-Stokes equations, Dimensional analysis and examples, and similitude. |  |
| 11 | Bukingham Pi theorem, Determining the Pi group. Fully developed laminar flow. |  |
| 12 | Steady unidirectional low, Poiseuille flow, Couette flow, Fully developed laminar flow inside pipe. |  |
| 13 | Flow over an inclined pipe, laminar flow between rotating circular cylinders, Flow over a flat plate, Similarity analysis. |  |
| 14 | Calculations of rate of deformation, volume flow rate, average velocity, vorticity, shear stress, Similarity transforms and solutions. |  |
| 15 | Stokes first problem and Stokes second problem by Laplace transform, Fourier transform, and substitution method. |  |
| 16 | Derivation of governing equations of second grade and Maxwell fluids, and Oldroyd-B fluid. Some applications with and without suction for different geometries. |  |