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| **Identification** | **Subject**  | PETE 338:Fluid Mechanics for Petroleum Engineers  |
| **Department** | Petroleum Engineering |
| **Program** | Undergraduate |
| **Term** | Spring, 2017 |
| **Instructor** | Masoud Mehrizadeh |
| **E-mail:** | mmehrizadeh@khazar.org  |
| **Phone:** | (+994 55) 462-5367 |
| **Classroom/hours** | Mondays and Wednesdays. |
|  | **Office hours** |  |
| **Prerequisites** | Engineering Mechanics |
| **Language**  | English |
| **Compulsory/Elective** | Compulsory |
| **Required textbooks and course materials** | ***Coretextbook:***Elemer Bobok, Fluid mechanics for petroleum engineers, Elsevier Science, 1993Donald Young and et. al, Brief Fluid: A Brief Introduction , 5th ed, Wiley, 2010 |
| **Course outline** | This course is designed to look at some of the more complex fluid flow problems that would typically be found in the oil and gas industry. We will look at relatively simple conditions that give a mathematical solution that shows some feature of the fluid flow; these include the flow of multiphase mixtures – gases/liquids, liquids/solids. |
| **Course objectives**  | ***Generic Objective of the Course:***This class provides students with an introduction to principal concepts and methods of fluid mechanics. Topics covered in the course include pressure, hydrostatics, and buoyancy; open systems and control volume analysis; mass conservation and momentum conservation for moving fluids; viscous fluid flows, flow through pipes; dimensional analysis; boundary layers, and lift and drag on objects. Students will work to formulate the models necessary to study, analyze, and design fluid systems through the application of these concepts, and to develop the problem-solving skills essential to good engineering practice of fluid mechanics in practical applications. The student will demonstrate the understanding of these fundamentals by solving problems dealing with: fluid properties, fluid statics, pressure on plane and curved surfaces, buoyancy and floatation, kinematics, systems, control volumes, conservation principles, ideal incompressible flow, impulse-momentum, and flow of a real fluid. **Quizzes** will be provided during the classes are based on the topic covered previously. Four quizzes will be provided during semester. |
| **Learning outcomes** | **By the end of the course the students should be able to learn :*** Characteristics and properties of fluid
* Basic characteristics of fluids in motion
* Flow properties of fluids
* Acceleration field and vorticity field
* Balance equations
* The perfect fluid
* Euler’s equation
* The Bernoulli equation
* Kelvin’s vortex theorem
* The Vazsonyi-Crocco equation
* Critical flow variables
* Two phase gas-liquid flow
* Compressible flow
* Shock waves in compressible flow
* Laminar flow
* Navier-Stokes equation
* Turbulent flow
* Reynolds equation
* One dimensional pipe flow
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| **Teaching methods** | **Lecture**  | x |
| **Group discussion** | x |
| **Experiential exercise** | x |
| **Simulation** | x |
| **Case analysis** | x |
| **Course paper** |  |
| **Others** |  |
| **Evaluation**  | **Methods** | **Date/deadlines** | **Percentage (%)** |
| **Midterm Exam** |  | 30 |
| **Case studies** |  |  |
| **Class Participation** |  | 5 |
| **Homework** |  |  |
| **Quiz (4)** |  | 20 |
| **Laboratory** |  |  |
| **Final Exam** |  | 45 |
| **Others** |  |  |
| **Total**  |  | 100 |
| **Policy** | * **Preparation for class**

The structure of this course makes your individual study and preparation outside the class extremely important. The lecture material will focus on the major points introduced in the text. Reading the assigned chapters and having some familiarity with them before class will greatly assist your understanding of the lecture. After the lecture, you should study your notes and work relevant problems.* **Withdrawal (pass/fail)**

This course strictly follows grading policy of the School of Economics and Management. Thus, a student is normally expected to achieve a mark of at least 60% to pass. In case of failure, he/she will be required to repeat the course the following term or year. * **Cheating/plagiarism**

Cheating or other plagiarism during the Quizzes, Mid-term and Final Examinations will lead to paper cancellation. **Professional behavior guidelines**The students shall behave in the way to create favorable academic and professional environment during the class hours. Unauthorized discussions and unethical behavior are strictly prohibited. |
| **Tentative Schedule** |
| **Week** | **Date/Day****(tentative)** | **Topics** | **Textbook/Assignments** |
| 1 | 13.02.2017&15.02.2017 | ***Fundamental concepts**** Introduction to Fluid Mechanics in Petroleum Engineering
* Properties of fluids
* The perfect gas: equation of state
* Compressibility
* Viscosity
* Surface tension
* Basic characteristics of fluids in motion
* Classification and description of fluid flow
* The roles of experimentation and theory in fluid mechanics

  | Chapter 1 |
| 2 | 20.02.2017&22.02.2017 | ***Flow properties of fluids+Quiz**** The fluid state
* The continuum model of fluids
* Variables of state
* Conductivity coefficients
 | Chapter 1 |
| 3 | 27.02.2017&29.03.2017 | ***Kinematics**** Eulerian and Lagrangian description of fluid motion
* The velocity fluid
* The acceleration field
* Motion of an infinitesimal fluid particle
* Rotational motion, vorticity field
* Relationships between the acceleration and the vorticity fields
* The transport theorem: the material derivative of a volume integral over a volume of flowing fluid
 | Chapter 2 |
| 4 | 06.03.2017&08.03.2017 (8th March is Holliday) | ***Balance equations**** The principle of conservation of mass
* The balance of momentum
* The balance of angular momentum
* The balance of kinetic energy
* The principle of conservation of energy
* The balance of entropy

Mechanical equilibrium of fluids | Chapter 3 |
| 5 | 13.03.2017&15.03.2017 | ***Perfect fluid flow+Quiz**** The perfect fluid
* Euler’s equation
* The Bernoulli equation
* Simple applications of the Bernoulli equation
* The Cauchy-Lagrange integral of Euler’s equation
* Kelvin’s vortex theorem
* The law of conservation of energy for perfect fluid flow
 | Chapter 4 |
| 6 | 18.03.2017&20.03.2017 | **Novruz Holliday** |  |
| 7 | 27.03.2017&29.03.2017 | ***Perfect fluid flow**** The Vazsonyi-Crocco equation
* Small perturbations at the speed of sound
* Dynamical similarity of ideal gas flows
* Critical flow variables
* Variation in area for isentropic flow
* High velocity gas flow in pipes with friction
 | Chapter 4 |
| 8 | 03.04.2017&05.04.2017 | ***Multiphase Flow**** Two phase gas-liquid flow
* Two phase liquid-solid flow
* Two phase liquid-liquid flow
 | Chapter 4 |
| 9 | 08.04.2017&16.04.2017 | ***Midterm Exam*** |  |
| 10 | 17.04.2017&19.04.2017 | ***Shock waves in compressible flow**** Shock surfaces
* Kinematics of motion of singular surfaces: the speed of displacement
* Weak singular surfaces in compressible flow
* Discontinuous balance equations at a shock surface
* Balance equations at a shock surface
* Changes in the variables of state across a shock surface
* The jump in the variables of state as a function of the Mach number
* Speed of propagation of shock surfaces
 | Chapter 5 |
| 11 | 24.04.2017&26.04.2017 | ***Laminar flow**** The flow of viscous fluids
* The Navier-Stokes equation
* The balance of kinetic energy for laminar flow
* The balance of internal energy for laminar flow
* Some general properties of incompressible viscous flow
* Steady incompressible flow in a cylindrical pipe
* Steady incompressible laminar flow in annuli
* Elementary boundary-layer theory
* Resistance of a solid sphere in laminar flow
 | Chapter 6 |
| 12 | 01.05.2017&03.05.2017 | ***Turbulent flow+Quiz**** The nature of turbulent motion
* Reynolds’s equation: the balance of momentum for turbulent flow***)***
 | Chapter 7 |
| 13 | 08.05.2017&10.05.2017 | ***Turbulent flow**** The balance of kinetic energy for turbulent flow
* Turbulent flow through pipes
* Turbulent boundary-layer flow
* Turbulent flow in annuli
 | Chapter 7 |
| 14 | 15.05.2017&17.05.2017 | ***One dimensional pipe flow**** One-dimensional approximation for flow in pipes
* Basic equations for one-dimensional flow in pipes
* Criteria for laminar, transitional and turbulent flow
* Head loss in straight cylindrical pipes
* Pressure loss of a low velocity gas flow
* Flow in pipes with mechanical energy addition
* Flow in pipes with heat exchange
* Pressure waves in one-dimensional pipe flow
 | Chapter 8 |
| 15 | 22.05.2017&24.05.2017 | ***Non Newtonian fluid flow+Quiz**** Specific types of flow behavior
* Laminar flow of pseudo-plastic fluids in pipes
* Bingham fluid flow in pipes
* Unsteady visco-elastic fluid flow in a cylindrical pipe
* The Rabinowitsch equation
* Laminar flow ofthixotropic fluids in pipes
* Pseudo-plastic fluid flow in annuli
* Turbulent flow ofnon-Newtonian fluids in pipes
 | Chapter 8 |
| 16 | 29.05.2017-31.06.2017(29th May is Holliday) | ***Flow of multiphase mixtures+quiz**** Properties of multiphase mixtures
* The continuity equation for multiphase mixtures
* The momentum equation for multiphase mixtures
* The mechanical energy equation for multiphase flow
* The total energy equation for multiphase flow
* Characteristic flow patterns
* Holdup relations fortwo-phase flow
* Determination ofpressure losses for two-phase flow in pipes
 | Chapter 10 |
|  |  | ***Final Exam*** |  |

This syllabus is a guide for the course and any modifications to it will be announced in advance.