SRI VENKATESWARA COLLEGE OF ENGINEERING

COURSE DELIVERY PLAN - THEORY 

| Department of Chemical Engineering | | LP: CH22302<br>Rev. No: 00 |
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| ~~B.E~~/B.Tech/~~M.E/M.Tech~~ : Chemical Engineering | Regulation: 2022 | Date: |
| PG Specialisation : NA | | 25.07.2023 |
| Sub. Code / Sub. Name : CH22302 - MOMENTUM TRANSFER | | |
| Unit : I | | |

**FUNDAMENTALS OF FLUID AND FLUID FLOW:** Fluid – properties of fluid – Continuum concept of fluid – Newton's law of viscosity, pressure and temperature dependence – classification of fluids – Newtonian fluid – Non-Newtonian fluid and their classification. Classification of fluid flow – Incompressible and Compressible flow – Steady, Unsteady, Uniform and Non – Uniform flow. Flow visualization – streamline, pathline, streak line, velocity and stress field.

**Objective:** To impart knowledge on fluid properties, types of fluid, types of fluid motion and the concept of fluid as continuum

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 1 | Fluid, Fluid mechanics, Importance of Fluid Mechanics, Difference between solids, liquids and gases, significance of units and basic concepts | T2,Ch1; Pg 1-9<br>R1,Ch 1, Pg. 1-5<br>T1, Ch. 1, Pg. 29-30 | PPT & BB |
| 2 | Fluid as continuum; Fluid properties-density, viscosity, surface tension and capillarity | T2,Ch 1; Pg. 1-22<br>R1, Ch.2, 20-23 | PPT & BB |
| 3 | Problems in fluid properties – classification of fluids | T2,Ch 1; Pg. 1-22<br>R1, Ch 1; Pg. 23 | PPT & BB |
| 4 | Types of fluid, Newtonian & non-Newtonian fluids – Time independent and Time dependent fluids- Compressible and incompressible | T1, Ch 3; Pg. 45-52; R1, Ch. 2, Pg. 34-39 | PPT & BB |
| 5 | Classification of fluid motion – uniform & non-uniform, steady & unsteady, | T2,Ch 1; Pg. 1-22<br>R1, Ch.2, Pg. 25-29; & Pg.38-40. | PPT & BB |
| 6 | Flow patterns – Stream line, streak line, path line, time line | T2,Ch 1; Pg. 1-22<br>R1, Ch.2, Pg. 25-29; & Pg.38-40. | PPT & BB |
| 7 | Velocity and stress field | R1,Ch 2; Pg.29-30 | PPT & BB |
| 8 | Problems on shear stress and velocity gradient | R1,Ch 2; Pg.29-30 | PPT & BB |
| 9 | Problems on shear stress and velocity gradient | R1,Ch 2; Pg.29-30 | PPT & BB |
| **Content beyond syllabus covered (if any):** Flow patterns | | | |

* Session duration: 50 minutes

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Unit : II

**FLUID STATICS AND FLUID KINEMATICS:** Fluid statics – Pressure concept, Hydrostatic equilibrium, Manometer and their types. Fluid flow - Differential analysis of fluid motion – Conservation of mass – Equation of continuity and Equation of motion - Euler's equation, Bernoulli equation and with correction for fluid friction – correction for pump work. Navier – Stokes Equations and Applications

**Objective:** To understand the forces acting on a fluid - fluid pressure, pressure measurement, buoyancy and the applications of Continuity equation, Bernoulli equation and Navier – stokes equation.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 10 | Fluid statics - Newton's law of motion, forces on fluid elements, Pascal's law of hydrostatics, | T1, Ch 2, Pg:31-44<br>R1, Ch. 3, Pg: 56-61 | PPT & BB |
| 11 | Hydrostatic equilibrium, Basic equation for pressure field | T1, Ch. 2, Pg. 31-34<br>R1, Ch. 3, Pg. 56-59 | PPT & BB |
| 12 | Pressure measurement – manometer, barometer, types of manometers | T1, Ch 2, Pg: 35-39<br>R1, Ch. 3, Pg. 61-68 | PPT & BB |
| 13 | Hydrostatic force on plane submerged surface, Hydrostatic forces on a curved submerged surface | T2, Ch 2, Pg: 63-87<br>R1, Ch. 3, Pg. 69-72 & 76-78 | PPT & BB |
| 14 | Problems - manometers and calculating the pressure drop | T2, Ch 2, Pg: 103-107<br>R1, Ch.3, Pg. 65-66 | PPT & BB |
| 15 | Problems - manometers and calculating the pressure drop | T1, Ch 2, Pg: 73-101<br>R1, Ch.3, Pg. 65-67 | PPT & BB |
| 16 | Scalar & Vector field, Differential analysis of fluid motion, Continuity equation | T1 Ch.3 Pg. 45-47,<br>T1, Ch 4, 68-74 | PPT & BB |
| 17 | Bernoulli equation, Bernoulli equation with pump work | T1, Ch. 4, 86-94<br>T2, Ch. 8, Pg. 202-204; R1, Ch. 6, Pg. 241-242 | PPT & BB |
| 18 | Bernoulli equation—problems based on continuity equation and Bernoulli's equation | T1, Ch. 4, 86-93<br>T2, Ch. 8, Pg. 202-204 | PPT & BB |

**Content beyond syllabus covered (if any):** Hydrostatic forces acting on a plane and curved surface

* Session duration: 50 mins

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Unit : III

**FLOW THROUGH CONDUITS, FIXED & FLUIDIZED BEDS:** Reynolds number, experiment and significance, Hagen Poiseuelle equation and Darcy-Weisbach equation; internal flow - flow through conduit – friction factor – friction factor chart – head loss due to friction, sudden expansion and contraction. External flows - Flow over a sphere – friction and pressure drag - flow through fixed and fluidized beds - Kozeny Carman equation – Blake Plummer equation and Ergun equation.

**Objective:** To impart knowledge on flow through pipes, conduits fittings, fixed and fluidized beds.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 19 | Reynolds number, experiment and significance | T1, Ch.3, Pg. 53-55<br>T2, Ch. 6, Pg. 341-346 | PPT & BB |
| 20 | Hagen Poiseuelle equation and Darcy-Weisbach equation; | T1, Ch. 5, Pg. 103-107<br>T2, Ch. 4, Pg. 268-270 | PPT & BB |
| 21 | Internal flow; flow through conduit; friction factor | T2, Ch.6, Pg. 346-349<br>R1, Ch.2, Pg. 43- 44 | PPT & BB |
| 22 | Friction factor-chart-Head loss due to friction, sudden expansion and contraction | T1,Ch. 5, Pg.114-141<br>R1, Ch. 8, Pg. 357-361 | PPT & BB |
| 23 | External flows-flow over sphere | T1, Ch. 7, Pg. 155-162<br>R1,Ch.9, Pg. 421- 444 | PPT & BB |
| 24 | Problems based on friction factor; Reynolds number Problems based on flow measurements | T2, Ch. 6, Pg. 351-352; 366-367<br>R1, Ch.9, Pg. 449-450<br>T2, Ch.6, Pg.377-382 | PPT & BB |
| 25 | Friction and Pressure drag | T1, Ch. 7, Pg. 155-162<br>R1, Ch. 9, Pg. 445-458 | PPT & BB |
| 26 | Pressure drop under laminar and turbulent flow conditions Packed bed and fluidized bed; Kozney Carman equation | T1, Ch.7, Pg. 163-167<br>T2, Ch.6, Pg.377-382 | PPT & BB |
| 27 | Blake Plummer equation and Ergun equation | T1, Ch.7, Pg. 163-167 | PPT & BB |
| **Content beyond syllabus covered (if any):** Flow over non cylindrical surfaces. | | | |

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Unit : IV

**TRANSPORTATION OF FLUIDS:** Flow measurement –classification flow measuring devices – Principle and working of Orifice meter, Venturi meter, Pitot tube and Rotameter. Brief introduction to non-conventional methods: Laser Doppler velocimetry, Particle image velocimetry, ultrasonic flow meters, electromagnetic flow meters. Valves, Types and characteristics of Valves; Pumps – Classification and working of Centrifugal pumps and Reciprocating pumps, Centrifugal pump: Cavitation and priming – performance characteristics – Net positive suction head – factors influencing selection of pump. Introduction to compressors, fans and blowers.

**Objective:** To impart knowledge on transportation of fluids using centrifugal and positive displacement pumps and measurement of flow.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 28 | Measurement of fluid flow-various devices and principles to measure fluid flow, non-conventional methods | T1, Ch. 8, Pg. 224-240<br>T1, Ch.6, Pg. 402-411<br>R3, Ch.2, Pg. 92 - 96 | PPT & BB |
| 29 | Venturimeter and Orificemeter | T1, Ch. 8, Pg. 224-227<br>R1, Ch. 8, Pg. 393-394 | PPT & BB |
| 30 | Orificemeter and Pitot tube | T1, Ch. 8, Pg. 227-232<br>R1, Ch.8, Pg. 395-396 | PPT & BB |
| 31 | Rotameter, Insertion meters, problems based on venturimeter, orificemeter | T1, Ch. 8, Pg. 232-240<br>R1, Ch.8, Pg. 387-391<br>R2, Ch. 8, Pg. 412 | PPT & BB |
| 32 | Characteristics of valves- Pumps-classification of pumps | T1, Ch. 8, Pg. 194-202<br>R1 Ch. 10, Pg. 516-521<br>T2, Ch.10, Pg. 693-724 | PPT & BB |
| 33 | Centrifugal pump-Cavitaion and Priming-NPSH-Reciprocating pump | T1, Ch. 8, Pg. 202-207<br>R1, Ch. 10, Pg. 526-529 | PPT & BB |
| 34 | Problems based on Pumps-calculation of efficiency of pump | T1, Ch. 8, Pg. 221-224<br>R1, Ch.10, Pg. 550-551 | PPT & BB |
| 35 | Factors influencing the efficiency of pump-characteristic curves-selection of pump | T1, Ch. 8, Pg. 208-214<br>R1, Ch.10, Pg. 516-524 & 529-530 | PPT & BB |
| 36 | Fans and Blowers | T1, Ch. 8, Pg. 214-220<br>R1, Ch. 10, Pg. 541-548 | PPT & BB |
| **Content beyond syllabus covered (if any):** System curve versus pump operating curve | | | |

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Unit : V

**TURBULENCE AND SIMILARITY:** Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition. Fundamental dimension of quantities, dimensional homogeneity – dimensional analysis: Physical significance of dimensionless numbers, Geometric – Kinematic and Dynamic Similarity.

**Objective:** To impart knowledge about the inter relation of fluid, heat and mass transport through analogies.

| Session No * | Topics to be covered | Ref | Teaching Aids |
|---|---|---|---|
| 37 | Introduction to Turbulence: Structure and Visualization | R1 Ch-16, Pg 469 - 480 | PPT & BB |
| 38 | Reynolds Decomposition | R1 Ch-16, Pg 481 - 487 | PPT & BB |
| 39 | Significance of dimensions and unit-Dimensional homogeneity | T1, Ch. 1, Pg. 16-19 R1, Ch. 1, Pg. 294-296 | PPT & BB |
| 40 | Dimensional analysis-Application- Rayleighs method-problem using Rayleigh method | T1, Ch. 1, Pg. 16-19 R1, Ch. 7, Pg. 296-298 | PPT & BB |
| 41 | Buckingham π-theorem-problems using Bukingham π theorem | T1, Ch. 1, Pg. 16-19 R1, Ch. 7, Pg. 297-298 | PPT & BB |
| 42 | Non-dimensionalization of basic equations | R1, Ch. 7, Pg. 290-296 | PPT & BB |
| 43 | Dimensionless numbers-Reynolds, Froude, Weber, Schmidt, Grashof number-Physical significance | R1, Ch. 7, Pg. 303-317 | PPT & BB |
| 44 | Geometric similarity and kinematic similarity | R1, Ch. 7, 304-309 | PPT & BB |
| 45 | Dynamic similarity; Problems based on similitude | R1, Ch. 7, 304-309 | PPT & BB |
| **Content beyond syllabus covered (if any):** Analogies between momentum, heat and mass transport | | | |

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**TEXTBOOKS:**


1. McCabe W.L, Smith, J C and Harriot. P "Unit Operations in Chemical Engineering", McGraw Hill, Seventh Edition, 2005.
2. White, F.M., "Fluid Mechanics", McGraw-Hill Inc., Seventh Edition, 2011.


**REFERENCES:**


1. Robert W. Fox and Alan T. McDonald, "Introduction to Fluid Mechanics" John Wiley & Sons, Inc, Fifth Edition, 2009.
2. Noel de Nevers, "Fluid Mechanics for Chemical Engineers", McGraw-Hill, Third Edition, 2005.
3. J. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall, 1999.
4. R. B. Bird, W. L. Stewart and E. L. Lightfoot, Transport Phenomena (Second edition), Wiley Singapore, 2002.
5. M. M. Denn, Process Fluid Mechanics, Prentice Hall, 1980.


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| Designation | Assistant Professor | Head of the Department |
| Date | 25/7/2023 | 31/07/2023 |
| Remarks *: | | |

Verified 25/7/23

* If the same lesson plan is followed in the subsequent semester/year it should be mentioned and signed by the Faculty and the HOD

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