MECHANICS OF FLUIDS
UNIT –I DEFINITIONS AND FLUID PROPERTIES

1.Define fluid.

A fluid is a substance having a property to flow easily.

Example: liquid, vapour, gas.

2. Define fluid mechanics.

Fluid mechanics is a branch of science which deals with property and behavior of fluids at rest and in motion.

3. Define fluid statics.

The study of fluids at rest is called fluid statics.

4. Define fluid kinematics.

The study of fluids in motion where pressure forces are not considered is called fluid kinematics.

5. What is the SI unit of density?

The SI unit of density is kg/m^3.

Example: Density of water is 1000 kg/m^3.

6. Define specific volume.

It is the ratio of volume to the mass of a fluid. It is denoted by υ.Its unit is m^3/kg.

$$\upsilon = \frac{\text{volume of fluid}}{\text{Mass of fluid}}$$

υ=V/mm^3/kg

7. Define specific gravity with respect to density.

It is the ratio of density of a fluid to density of a standard fluid. It is denoted by s.

8. Define viscosity.

It is defined as the resisting property of liquid to its flow corresponding to its adjacent layers.

9. Which one of the following has high viscosity, (i) water or (ii) lubricating oil?

Lubricating oil has high viscosity.

10. Define poise

Poise is the other name of unit of viscosity in CGS system which equals sec/cm^2.

11.Give the classification of fluids?

Classification of fluids are,

(i) Ideal fluid (ii) Real fluid (iii) Newtonian fluid

(iv) Non Newtonian fluid (v) Ideal plastic fluid.

12. What is real fluid?

A fluid which has viscosity is a real fluid. All fluid in practice are real fluids.

13.What is non Newtonian fluid?

A real fluid in which shear stress is not proportional to rate of shear strain.

$\tau = \mu \, du/dy$

τ = Shear stress μ = viscosity of the fluid

du = change in velocity dy = change in perpendicular distance.

14.What is compressibility?

Compressibility is the property of fluid which undergoes change in volume under various pressure conditions.

15. Define compressible fluid.

A liquid is considered to a compressible fluid only when there is a change in volume of liquid that occurs under large pressure variation .

16. Define compressibility.

It is also defined of reciprocal of bulk modulus of elasticity (k). i.e,

compressibility = 1/k .

k= compressive stress / volumetric strain

17.Define capillarity.

It is the phenomenon of rise or fall of liquid surface relative to out side liquid surface

18.Give the types of gas laws.

The types of gas laws are,

(i) Boyles law

(ii) Charles law

19. Give the equation for capillarity fall in an glass tube.

The equation for the capillarity fall is

$$H = \frac{4\sigma\cos\theta}{\rho g d} \text{ metre.}$$

20. Give some properties of fluid?

Some properties of fluids are density, specific weight, viscosity, surface tension and capillarity

UNIT-II FLUID STATICS & KINEMATICS

1) Define forced vertex flow

It is defined as that type of vertex flow in which some external torque is required to rotate the fluid mass.

2) Define free vertex flow? Give examples?

When no external torque is required to rotate the fluid mass, that type of flow is called free vertex flow.

Example.

1.Flow of liquid through a hole provided at the bottom of a container.

2.A whirlpool in a river.

3) Write the equation of motion for vertex flow.

$dp=\rho(v^2/r)dr-\rho gdz$

This equation of variation of pressure of a rotating fluid in any plane.

Where

r-Radius of element. p-Pressure variation.

ρ-density of liquid. g-Acceleration due to gravity.

4) Write the equation of forced vortex flow.

$Z=(\omega^2 r^2)/2g$

Where

Ω-Angular velocity.

r-Radius of parabola. z-Height of parabola. g-Acceleration due to gravity.

5) Write the equation of closed cylindrical vessels?

$Z=(\omega^2 r^2)/2g$

Volume of air before rotation = Volume of closed vessel-Volume of liquid in vessel.

Volume of air after rotation = Volume of paraboloid formed.

6) What are the forces present in a fluid flow?

Fg-Gravity force

Fp-Pressure force

Fv-Force due to viscosity

Ft-force due to turbulence.

Fc-Force due to compressibility.

7) Give the Euler's equation of motion.

$(dp/\rho)+gdz+vdv=0$

8) What are the assumptions made in deriving Bernouillie's equation?

1.The fluid is ideal 2.The flow is steady.

3.The flow is incompressible. 4.The flow is irrotational.

9) What is bernouillie's equation for real fluid?

$(p_1/\rho g)+(v_1^2/2g)+z_1=(p_2/\rho g)+(v_2^2/2g)+z_2+h_l$

where hl is the loss of energy (p/ρg)-Pressure energy. (v2/2g)=Kinetic energy. z-Datum energy.

10) State the application of Bernouillie's equation .

It has the application on the following measuring devices.

1.Orifice meter. 2.Venturimeter. 3.Pitot tube.

11) Define venturimeter

A venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe.It consists of three parts,They are short converging part ,and throat a diverging part.

12) What arrangements should be adopted to find the velocity at any point in a pipe by a pitot tube?

The arrangements to be adopted are (1)Pitot tube along with vertical piezometer tube.(2)Pitot tube connected with piezometer.(3)Pitot tube and vertical piezometer connected with a differential U-tube manometer.

13) What purpose orifice meter is used? Define it?

It is a device used for measuring the rate of flow of a fluid through a pipe.Orificemeter consist of a flat circular plate which has a circular sharp edged hole called orifice meter.

14) State momentum equation and Impulse momentum equation.

The momentum equation states that net force acting on a fluid mass in equal to the change in momentum per second in direction.This is given as

$$F=d(mv)/dt$$

The impulse momentum equation is given by $F.dt=d(mv)$

15) State moment of momentukm equation.

The moment of momentum equation states that the resultant torque acting on a rotating fluid is equal to rate of change of moment of the momentum. Mathematically it is given as.

$$T=pq(v_2r_2-v_1r_1)$$

16) Define pitot tube and give its working principle.

The pitot tube consist of a glass tube bent at right angles.It is based on the principle that if the velocity of flow at a point becomes zero the pressure there is increased due to conversion of kinetic energy into pressure energy.

17) State Bernouillie's theorem.

It states that in a steady ideal flow of an incompressible fluid the total energy at any point of the fluid is constant. The total energy consists of pressure energy, Kinetic energy and potential energy.

18) Give the expression for actual velocity in pitot tube.

$(v_1)=c_v(2gh)^{\wedge 1/2}$

c_v-Co-efficient of pitot tube. (v_1)act-Actual velocity. $(2gh)^{\wedge 1/2}$ -Theoritical velocity.

UNIT-III FLUID DYNAMICS

1) What are the types of fluid flows?

The fluid flow is classified as,

(1)Steady and unsteady flow. (2) Uniform and non-uniform flow.

(3)Laminar and turbulent flow. (4) Compressible and incompressible flow.

(5)Rotational and irrotational flow. (6) One,two and three dimention flow.

2) Differentiate between steady and unsteady flow

Steady flow	Unsteady flow.
Steady flow is defined as that type of which the fluid characteristics velocity,pressure etc at a point do not change with time	Unsteady flow is that type of flow in flow in which the velocity.pressure at a point like changes with time.
$(dv/dt)(0,0,0)=0$	$(dv/dt)(0,0,0)=/0$

3) Differentiate between uniform and non-uniform flow

Uniform flow	Non-uniform flow
It is defined as that type of flow in which the velocity at any given with time does not change with respect space.	It is defined as that type of flow in which the velocity at any given time changes respect to time.
$(dv/dt)t=constant=0$	$(dv/dt)t=constant=/0$

4) Differentiate between laminar and turbulent flow

Laminar flow.	Turbulant flow
Laminar flow is defined as that type flow in which the fluid particle move well defined path or streamline and all the streamline are straight and parallel	It is defined as that type of flow in which of the fluid particle moves in a zig-zag way
Reynolds number<2000	Reynolds number>4000.

5) Define cmpressible flow.

Compressible flow is that type of flow in which the density of the fluid changes from point to point.(eg)Flow of gasses through orifice nozzle and gas turbine.

6) Define incompressible flow.

Incompressible flow is that type of flow in which the density is constant for the fluid flow.(eg)Subsonic aerodynamics.

7) Define rotational flow.

Rotational flow is that type of flow in which in which the fluid particle flowing along streamlines, also rotate about their own axis.

8) Define irrotational flow.

It is that type of flow in which the fluid particle while flowing along streamlines, do not rotate about their own axis.

9) Define one dimensional flow.

One dimentional flow is that type of flow in which the flow parameter such aas velocity is a function of time and one space co-ordinate only,say X. $U=F(x),V=0,w=0$.

10) Define two dimensional flow.

It is that type of flow in which the velocity is a function of time and two rectangular space say X and Y. $u=F_1(X,Y),V=F_2(X,Y)$ and $w=0$.

11) What is three dimensional flows?

A three dimensional flow is that type of flow in which the velocity is a function of time and three mutually perpendicular directions.

$U=F_1(X,Y,X),v=F_2(X,Y,Z),w=F_3(X,Y,Z)$.

U,v,w are velocity components inX,Y,Z direction respectly.

12) What is total acceleration of three dimensional fluid flow?

If a_X, a_Y,a_Z are the total acceleration in x,y,z directions.

Then

$a_X=du/dt=u.(\partial u/\partial x)+v.(\partial u/\partial y)+w.(\partial u/\partial z)+\partial u/\partial t$.

$a_Y=dv/dt=u.(\partial v/\partial x)+v.(\partial v/\partial y)+w.(\partial v/\partial z)+\partial v/\partial t$.

$a_Z=dw/dt=u.(\partial w/\partial x)+v.(\partial w/\partial y)+w.(\partial w/\partial z)+\partial w/\partial t$

13) Define local acceleration.

It is defined as the rate of increace of velocity with respect to time at a given point in a flow field.

14) Define convective acceleration.

It is defined as the rate of change of velocity due to the change of position of fluid particle in a fluid flow.

15) Define velocity poyential function

It is defined as a scalar function of space and time such that its negative derivative with respect to any direction gives the fluid velocity in that direction.It is denoted by Φ.

$U= -\partial\Phi/\partial x, v=-\partial\Phi/\partial y, w=-\partial\Phi/\partial z.$

U,v,w are the velocity in x,y,z direction.

16) Mention the properties of potential function.

1.If velocity potential exists, The flow should be irrotational.

2.If velocity potential satisfies the laplace equation,It represents the possible steady incompressible irrotational flow.

17) Define stream function.

It is defined as the scalar function of space and time, such that its partial derivative with respect to any direction gives the velocity component at right angles to that direction.

18) Mention the properties of stream function.

1.If stream function exists,itn is a possible case of fluid flow which may be rotational.

2.If stream function satisfies laplace equation, It is a possible case of an irrotational flow.

19) What is equipotential line?

A line along which the velocity potential Φ is constant is called equipotential line.

20) Give the relation between stream function and velocity potential function.

$u=-\partial\Phi/\partial x$ and $v = \partial\Phi/\partial y$ $u=-\partial\Psi/\partial y$ and $v=-\partial\Psi/\partial x$

$u=-\partial\Phi/\partial x=-\partial\Psi/\partial y$ and $v = -\partial\Phi/\partial y=-\partial\Psi/\partial x$

Hence $\partial\Phi/\partial x=\partial\Psi/\partial y$

$\partial\Phi/\partial y=\partial\Psi/x$

UNIT -IV BOUNDARY LAYER & FLOW THROUGH PIPES

1) What do you meant by viscous flow ?

A flow is said to be viscous if the Renold's number is less than 2000 (or) the flows in layers ie. R_e <2000 .

2) What is Hagen poiseuille's formula ?

$P_1-P_2 / \rho g = h_f = 32 \mu\tilde{U}L / \rho g D\hat{}2$ The expression is known as Hagen poiseuille.

3) Define kinetic energy correction factor

Kinetic energy factor is defined as the ratio of the k i n e t i c energy of the flow per sec based on actual velocity across a section to the kinetic energy of the flow per sec based on average velocity across the same section. It is denoted by (α).

K. E factor (α) = K.E per sec based on actual velocity / K.E per sec based on Average velocity .

4) Define momentum correction factor.

It is defined as the ratio of momentum of the flow per sec based on actual velocity to the momentum of the flow per sec based on average velocity across the section . It is denoted by

(β) = Momentum per sec based on actual velocity

5) Give an expression for loss of head at the entrance of the pipe

$h_i = 0.5 V^2/2g$

where

h_i = Loss of head at entrance of pipe .

V = Velocity of liquid at inlet and outlet of the pipe .

6) Differentiate between Laminar & Turbulent Flow

Laminar Flow	Turbulent Flow
1)Laminar flow is possible only at low velocities and high viscous fluids .	Is the flow is possible at both velocities and low viscous fluid .
2)In such type of flow fluid particle moves in laminas or layers gliding smoothly over the adjacent layer .	3) In that type of flow fluid particle move in a zig – zag manner .
3)A flow is said to be laminar if Renolds number is less than 2000 is known as Laminar flow.	A flow is said to be turbulent if Renolds number is greater than 4000 is known as Turbulent flow

7) Derive the expression for drop of pressure for a given length of a pipe

$P_1-P_2 = 32\ \mu\bar{U}L / \rho g D^2$

Where, P_1-P_2 is drop of pressure.

8) What are the factors to the determined when viscous fluid flows through the circular pipe ?

The factors to the determined as

i. Velocity distribution across the section .
ii. Ratio of maximum velocity to the average velocity .
iii. Shear stress distribution .
iv. Drop of pressure for a given length .

9) What do you understand by the terms a) major energy losses , b) minor energy losses

Major energy losses : -

This loss due to friction and it is calculated by Darcy weis bach formula and chezy's formula .

Minor energy losses :- This is due to

i. Sudden expansion in pipe .
ii. Sudden contraction in pipe .
iii. Bend in pipe .
iv. Due to obstruction in pipe .

10) How will you determine the loss of head due to friction in pipes?

Darcy weis-bach

$h_f = 4fLV^2 /2gD$ Where

h_f = Loss of head due to friction .

f = Coefficient of friction in pipe .

D = Diameter of pipe .

L = Length of the pipe

V = Mean velocity of flow . Chezy's formula

$V = C\sqrt{mi}$

11) Give an expression for loss of head due to sudden contraction

$h_C = 0.5\ /2g V^2$

Where

h_C = Loss of head due to sudden contraction .

V = Velocity at outlet of pipe.

UNIT-V SIMULATION AND MODEL STUDY

1.What is net flow?

A grid obtained by drawing a series of equipment lines and steam lines is called a flow net. The flow net is an important tool is analysis two dimensional. irrotational flow problems.

2.What are the types of motion of fluid particle?

i. Linear translation or pure translation.
ii. Linear Deformation.
iii. Angular Deformation
iv. Rotation.

3.What are linear translation?

It is defined as the movement of a fluid element in such a way that it moves bodily from one position to represents in new position by a'b'&c'd' are parallel.

4.What is linear deformation?

It is defined as the deformation of a fluid element in linear direction when the element moves the axes of the element in the deformation position and undeformation position are parallel but their lengths changes.

5.Define rotation of fluid element.

It is defined as the movement of a fluid element in such a way that both of rotate in same direction. It is equal to $1/2(\partial v/\partial x-\partial u/\partial y)$ for a two-dimensional element x, y plane.

$\omega_Z=1/2(\partial u/\partial x-\partial u/\partial y)$ $\omega_X=1/2(\partial w/\partial y-\partial v/\partial z)$ $\omega_Y=1/2(\partial u/\partial z-\partial w/\partial x)$

6..Define vortex flow mention its types.

Vortex flow is defined as the flow of a fluid along a curved path or the flow Of a rotating mass of fluid is known as votex flow.

i.Forced vortex flow. ii. Free vortex flow.

7..Define free vortex flow.

When no external torque is required to rotate the fluid mass that type of flow Is called free vortex flow.

8.Define forced vortex flow

Forced vortex flow is defined as that type of vortex flow in which some external torque is required to rotate the fluid mass.The fluid mass in the type of flow rotates at constant Angular velocity 'w'.The tangential velocity of any fluid particle is given by v=cosr.

9. What are the forces present in the fluid flow?

a) Gravity force (F_g)
b) Pressure force (F_p)
c) Force due to viscosity(F_v)
d) Force due to turbulence(F_t)
e) Force due to compressibility(F_o)

10.What are the assumptions made in the deviation of Bernoulli's equation?

i The fluid is ideal.
ii The flow is steady.
iii The flow is incompressible.
iv The flow is irrotational.

11.State Bernoulli's theorem.

It states that in a steady,ideal flow of an incompressible fluid,the total energy at any point of the fluid is constant. It is written as, $P/w+v^2/2g+z=$constant.

12.What is Venturimeter?Mention its parts.

Venturimeter is a device used for measuring the rate of flow of a fluid flowing through a pipe.

Parts:

i A short convergant part.
ii Throat.
iii Divergant part.

13.What is Orifice meter?

Orifice meter is a device used for measuring the rate of flow of fluid through a pipe.It is a cheaper device as compared to Venturimeter.It works on the same principle of Venturimeter.

14 .What is pitot tube?

Pitot tube is a device used for measuring the velocity of flow at any point in a pipe or a channel.

15.What is momentum equation?

It is based on the law of conservation of momentum or on the momentum principle

It states that,the net force acting on a fluid mass is equal to the change in momentum of flow per unit time in that direction.

16.State momentum of momentum equation.

It states that the resulting torque acting on a rotating fluid is equal to the rate of change of moment of momentum.

PART - B

UNIT -I DEFINITIONS AND FLUID PROPERTIES

1. What are the methods and instruments available for the measurement of pressure?
2. Define compressibility and prove that it is reciprocal of bulk modulus of elasticity.
3. Derive the continuity equation for three dimensional flow in X,Y and Z co-ordinate system.
4. Explain with neat sketch Surface tension and capillarity ad obtain necessary expressions.
5. Differentiate between absolute pressure and gauge pressure and give suitable sample conversion.

UNIT –II FLUID STATICS & KINEMATICS

1. (a) Define stream line, path line, and streak line.

   (b) The velocity potential function (φ) is given by an expression $\varphi = xy^2 - x^3y/3 + x^2 - y^2$. Find the velocity component in x and y direction, also check for a possible case of flow.
2. Derive continuity equation from principle of conservation of mass.
3. The velocity component for a two dimensional incompressible flow are given by $u = 3x - 2y$ and $v = -3y - 2x$ Show that the velocity potential exists. Determine the velocity potential function and stream function.
4. Derive the continuity equation for a three dimensional incompressible flow.
5. The water level in a canal is regulated by a flat tipper gate inclined at a 60^o to the bed. The tipper takes place about a fulcrum placed at a height of 1m from the bed when the water level in the canal reaches a maximum value H. Determine H.

UNIT –III FLUID DYNAMICS

1. Derive from the basic principle the Euler's Equation of motion in Cartesian co-ordinate system and deduce the equation to Bernoulli's theorem for steady irrotational flow.
2. Derive Darcy-Weisbach formula for frictional loss in a pipe.
3. What power is required per kilometer of an 8.0 cm pipe line to maintain a flow of 5.0 lps of castor oil having a dynamic viscosity of 9.8 Poise? Assume flow in laminar.

4. Derive Euler's Equation of motion along a stream line and hence derive the Bernoulli's theorem.
5. Derive the Hagen-Poiseuille equation and state the assumptions made.

UNIT –IV BOUNDARY LAYER AND FLOW THROUGH PIPES

1. A compound piping system consists of 1800m length with 0.5m diameter, 1200m length with of 0.40m diameter ad 600m length with of 0.3m diameter. pipe connected in series. Convert the system to (i) an equivalent length of 0.4m diameter pipe and (ii) an equivalent size of pipe of 3600m length.
2. Derive Von Karman Momentum integral equation.
3. If the velocity profile in a laminar boundary is given by $u/v = 2(y/\delta) - (y/\delta)^2$
4. A pipe system consist of three pipes arranged in series, the length of the pipe are 1200m, 750m, and 600m. Diameters are 750mm, 600mm, and 450mm respectively. Transform the system to an equivalent 450mm diameter pipe; also determine an equivalent diameter for the pipe 2550m long.
5. What is the separation of boundary layer? When it occurs? Discuss the method for the control of boundary layer separation.

UNIT –V SIMILITUDE AND MODEL STUDY

1. Using Buckingham's π theorem, show that the drag force $F_D = \rho L^2 V^2 \varphi$ (Re,M) I which $Re = \rho VL/\mu$; $M = V/C$; ρ = fluid mass density ; L = chord length ; V = velocity of aircraft ; μ = fluid viscosity ; C = sonic velocity $= \sqrt{(K/\rho)}$ where K = bulk modulus of elasticity.
2. The resistance 'R' experienced by a partially, submerged body depends upon the velocity 'V', length of the body 'l', viscosity of fluid 'μ', density of the fluid 'ρ' and gravitational acceleration 'g' ; Obtain expression for R.
3. State the reasons for construction distorted model of rivers and discuss the various types of distortion in models. What are the merits and demerits of distorted models as compared to undistorted model?
4. Derive the relation using Buckingham's π theorem $F = \rho U^2 D^2 f(\mu/(UD\rho), ND/U)$.