1

Fluid Mechanics

A fluid is a substance that is capable of flowing, conforms to shape of containing vessel, deforms continuously when it is subjected to even a smallest shear stress. An ideal fluid is frictionless and incompressible. For *Newtonian fluids,* there is a linear relation between the magnitude of applied shear stress and the resulting rate of deformation. **Viscosity** is that property of a fluid by virtue of which it offers resistance to shear. Unit of viscosity is poise or 1 gm/cm/sec. $\left(1 \text{ poise} = \frac{0.1 Ns}{m^2}\right)$. The absolute viscosity of water at 20.2°C is 1 centipoise and of air is 0.17 centipoise. $\left(1 \text{ centipoise} = \frac{1}{100} \text{ poise}\right)$.

Kinematic viscosity is the ratio of absolute or dynamic viscosity and the density. Its unit is stoke which is equal to 1 cm^2/sec. Viscosity is practically independent of pressure and depends upon temperature only.

Shear stress = $\mu \frac{du}{dx}$ (μ = coefficient of viscosity *Pa s* (Ns/m^2)).

$\frac{du}{dx}$ is known as velocity gradient or rate of shear strain and it is zero for fluids at rest. The law which states that shear stress is proportional to $\frac{du}{dx}$ is called *Newton's law of viscosity*. Fluids following this are known as **Newtonian fluids** and others non-newtonian fluids. An ideal fluid offers no resistance to flow but real fluid does. Thus viscosity is zero for ideal fluid but not for real fluid.

For non-newtonian fluids, shear stress $= A\left(\frac{du}{dx}\right)^n + B$,

where, A, B and n are constants.

Liquid molecules are attracted to each other by equal forces in all directions. However on the surface, they are subjected to an inward attraction which is not balanced by the outward attraction. This causes the liquid surface to seek a minimum possible area by exerting surface tension tangent to the surface over the entire surface area. **Surface tension** is expressed as force per unit length. Small amounts of salt dissolved in water tend to increase the electrolytic content and hence the surface tension. Organic matter like soap decreases the surface tension in water. Surface tension of water is 74.16 dyn/cm at 0°C, 71.32 at 20°C, 60.71 at 90°C.

The phenomenon of rising water in a tube of smaller diameter dipped in water, is called **capillarity of water.**

The capillary rise of water in a tube, may be calculated from the formula

$$h = \frac{4\sigma \cos \alpha}{w \,.\, d}$$

where, h = capillary rise, d = inner diameter of the tube,

α = angle of contact of water surface,

σ = force of surface tension in N/m per unit length of the periphery.

Pressure difference between inside and outside of a liquid drop of dia 'd' is $4\sigma/d$, between jet of dia 'd' and of unit length $2\sigma/d$, and for soap bubble $\Delta p = 8\sigma/d$.

The force per unit area exerted by water on the sides and bottom of its container is called **water pressure.** The intensity of pressure at any point in water, is proportional to its depth from the surface, *i.e.* $p = wh$.

where, w is the value of specific weight of water and h is the depth of the point below water surface.

According to **Pascal's law**, the intensity of pressure at any point in a fluid at rest, is the same in all directions.

The **compressibility** of a liquid is expressed by its bulk modulus of elasticity K, which is equal to $\frac{-dp}{dv/v}$. Capillary attraction is caused by *surface tension* and by the relative value of adhesion between liquid and solid to cohesion of the liquid. If a liquid has greater adhesion than cohesion, it would wet the surface.

Gauge pressure is measured with reference to atmospheric pressure and absolute pressure is measured with reference to complete vacuum.

Absolute Pressure = Atmospheric Pressure + Gauge Pressure

Local atmospheric pressure can be measured by a mercury barometer or by an aneroid barometer.

For differential manometer shown in Fig. 1.1.

$$h_A - h_B = h_1S_1 + h_2S_2 + h_3S_3$$

where S_1, S_2, S_3 are the applicable specific gravities of the liquids in the system.

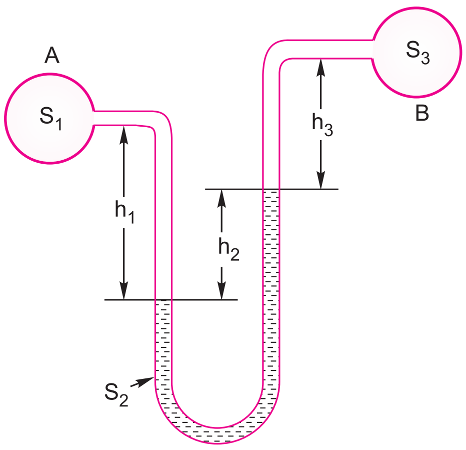


Fig. 1.1. Differential manometer.

The continuous impingement of vapour molecules on the liquid surface creates a pressure on the liquid surface known as the **vapour pressure.**

In a closed system, water vaporises rapidly in regions where the pressure drops below the vapour pressure. This phenomenon is known as **cavitation.** The vapour bubbles formed in cavitation usually collapse in a violent manner, which may cause considerable damage to the system.

According to **Pascal's law,** a pressure applied at any point in a liquid at rest is transmitted equally and undiminished is all directions to every other point in the liquid.

Variation of static pressure $dp/dy = \rho g$; gauge pressure at depth h is = wh.

The total **hydrostatic pressure force** on any submerged plane surface is equal to the product of the surface area and the pressure acting at the centroid of the plane surface.

For a horizontal area subjected to static fluid pressure, the resultant force passes through the centroid of the area. The magnitude of force exerted on one side of a plane area, submerged in a liquid is the product of the area and the pressure at its centroid. The point where the resultant force acts is known as **centre of pressure.**

The centre of pressure of any submerged plane surface is always below the centroid of the surface.

The location of centre of pressure y_P in case of vertically immersed plane surface is given by

$$y_P = \frac{I_G}{\bar{y} \,.\, A} + \bar{y}$$

where, I_G = M.I. of area through centroid axis parallel to liquid surface.

and $\bar{y}$ = Depth of C.G. of the area below liquid surface.

A = Area.

Centre of pressure on an inclined immersed plane surface

$$y_P = \frac{I_G \sin^2 \theta}{A\bar{y}} + \bar{y}$$

and $x_P = x$, if the area is symmetrical about the centroid axis parallel to the x-axis. If not,

$$x_P = \frac{\bar{I}_{xy}}{\bar{x}} + \bar{x}$$

where, $\bar{I}_{zy} = I_{xy} - \overline{xy}\ A$

I_{xy} = product of inertia

Horizontal component of pressure force on a curved surface is equal to the pressure force exerted on a projection of the curved surface. The vertical plane of projection is normal to the direction of the vertical component.

The vertical component of pressure force on a curved surface is equal to the weight of liquid vertically above the curved surface and extending up to the free surface. Line of action of the vertical force passes through the centroid of the volume, real or imaginary, that extends above the curved surface upto the real or imaginary free surface.

For horizontal surface, $F = whA$

Force on vertical surface, $F = \frac{1}{2} whA$.

Depth of centre of pressure from free surface = $\frac{2}{3}h$.

According to **Archimedes**, the weight of a submerged body is reduced by an amount equal to the weight of the liquid displaced by the body.

A floating body is partially submerged due to the balance of the body weight and the buoyancy force.

Buoyant force is the resultant force exerted on a body by a static fluid in which it is submerged or floating. Buoyant force acts through the centroid of the displaced volume of fluid, known as *centre of buoyancy*. This holds good for both submerged and floating bodies.

A body has linear stability when a small linear displacement in any direction sets up restoring forces tending to return the body to its original position. A body may float in stable, unstable or neutral equilibrium. A submerged body is rotationally stable only when its c.g. is below the centre of buoyancy.

The stability of a floating body is determined by the relative position of the centre of gravity of body and the centre of buoyance (centre of gravity of the liquid volume displaced by the body).

Metacentre '*M*' is the point where the buoyant force and the centre line intersect. When a body is given a small angular displacement, it starts oscillating about metacentre. Body is stable, when M is above G, unstable when M is below G, and in neutral equilibrium when M is at G. The distance between the metacentre and c.g. is known as metacentric height.

Metacentric height = $\frac{I}{V}$ – Distance between c.g. and centre of buoyancy

I = M.I. of the plan of floating body at water surface

and V = Volume of submerged body in water.

The line of vertical buoyancy force action meets the axis of symmetry at metacentre. Distance between metacentre and centre of gravity is called *metacentre height* and it is a measure of the floatation stability of the body. A floating body is stable if centre of gravity is below the metacentre, otherwise it is unstable. A submerged body is stable if the centre of gravity is below the centre of buoyancy.

Forced vortex motion is constituted when a fluid rotates about an axis, moving as a solid, and every particle of fluid has same angular velocity. In *free-vortex* motion, each particle moves in a circular path with a speed varying inversely as the distance from the centre. For free vortex $v \times r$ = constant.

In forced vortex motion, the vertical depth varies as the square of the radius from centre, and accordingly the surfaces of equal pressure are paraboloids of revolution. The shape of paraboloid depends only upon the angular velocity.

Depression (or rise) of liquid in forced vortex = $\dfrac{\omega^2 R^2}{2g}$

The volume of water which flows through a section of a channel or pipe per second, is known as **discharge.**

According to **fundamental equation of liquid flow,** or equation of continuity of liquid flow, if an incompressible liquid flows continuously through a pipe or channel, the discharge remains the same irrespective of the areas of cross-section.

The path followed by a fluid particle in motion, is called *path line.*

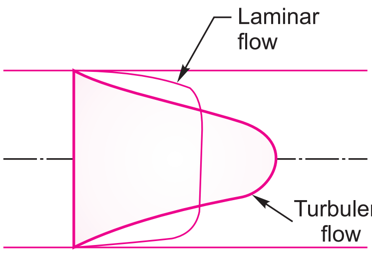


Fig. 1.2. Velocity profile.

The imaginary line, tangent to which, at any point indicates the direction of motion at that point, is called *stream line.*

The instantaneous positions of all fluid particles which have passed through a given point, is called *streak line.*

The line joining the points of equal potential on adjacent flow lines, is called *potential line* or *equipotential line.*

The pattern obtained by the intersection of stream lines and potential lines, is called *flow net.*

The flow in which the velocities of liquid particles at all sections of the pipe or channel are equal, is called **uniform flow.** This generally refers to flows in channels.

The flow in which velocities of liquid particles at all sections of the pipe or channel are not equal, is called a **non-uniform flow.**

The flow in which the quantity of liquid flowing per second is constant is called **steady flow.**

The flow in which the quantity of liquid flowing per second is not constant is called **unsteady flow.**

The flow in which paths of individual particles of liquid do not cross each other, is called *stream line flow* or **laminar flow.** For laminar flow, Reynold's number is less than 2000.

The flow in which paths of individual particles cross each other and particles do not have definite paths, is called **turbulent flow.** For turbulent flow, Reynold number is more than 4000.

The flow whose stream lines may be represented by straight lines, is called *one-dimensional flow.*

The flow of liquid whose stream lines may be represented by a curve, is called *two-dimensional flow.*

The flow of liquid, whose stream lines may be represented in space along three mutually perpendicular axes, is called *three dimensional flow.*

According to Reynold, the transition from laminar to turbulent flow in a pipe depends on velocity (V), pipe diameter (D) and kinematic viscosity (γ) of the fluid.

Reynolds number = $\dfrac{DV}{\gamma}$

At critical Reynolds number of 2000 flow, starts changing from laminar to turbulent.

Rate of energy loss in *pipe flow* varies as a function of the Reynolds number and the roughness of the pipe.

According to **continuity equation**

$$\text{Flow } Q = AV = A_1V_1 = A_2V_2$$

According to **Bernoulli's equation**

$$\frac{V_1^2}{2g} + \frac{P_1}{\rho g} + h_1 = \frac{V_2^2}{2g} + \frac{P_2}{\rho g} + h_2$$

According to **Darcy-Weisbach formula**

$$h_f = f\left(\frac{L}{D}\right)\frac{V^2}{2g}$$

where, h_f = energy loss through friction in pipe line,

f = friction factor

L and D = length and diameter

and V = velocity

The sum of the potential head, kinetic head and pressure head of a liquid particle, is called its total head *i.e.*

$$H = Z + \frac{v^2}{2g} + \frac{p}{w} \text{ metres of liquid}$$

According to Bernoulli's theorem, for a perfect incompressible liquid flowing in a continuous flow, the total energy of a particle remains the same; while the particle moves from one point to another. Mathematically,

$$Z + \frac{v^2}{2g} + \frac{p}{w} = \text{constant}$$

Discharge in pipes may be determined either by inserting a venturimeter or an orifice meter.

Discharge through venturimeter

$$Q = C_d\, a_2\, v_2 = C_d \,.\, \sqrt{2gh} \,.\, \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}$$

a_1 and a_2 are areas before and at throat

C_d is the coefficient of discharge of the venturimeter.

Pitot tube is used to measure velocity of fluid in a pipe or channel, $V = C_v\sqrt{2gh}$.

Orifice is a smaller opening on the side or at bottom of a tank. Mouthpiece is a short length of a pipe is 2—3 times its diameter in length, fitted in a tank of vessel containing the fluid.

The various hydraulic coefficients are:

Coefficient of contraction. The ratio of the area of the jet at *vena-contracta* to the area of the orifice opening, is known as *coefficient of contraction*. Its average value is taken as 0.64.

Coefficient of velocity. The ratio of the velocity of the jet at vena-contracta to the theoretical velocity, is known as coefficient of velocity. Its average value is taken 0.97. In terms of coordinates (x, y) for vena-contracta, $C_v = \dfrac{x}{\sqrt{4yH}}$, H = height of fluid in tank.

Coefficient of discharge. The ratio of actual discharge through an orifice to the theoretical discharge, is known as coefficient of discharge. Its average value is taken as 0.62.

Coefficient of resistance. The ratio of loss of head in the orifice to the head of water available at the orifice exit, is known as coefficient of resistance. It is treated equal to zero for all practical purposes.

In laminar flow, fluid particles move along smooth paths in laminar, or layers, with one layer gliding smoothly over an adjacent layer. The losses in laminar flow vary proportional to velocity.

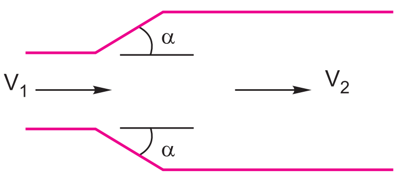


Fig. 1.3

Viscosity. In fluids there is cohesion and interaction between molecules which results in a shear force between adjacent layers moving at different velocities and between a moving fluid and a fixed wall. This results in friction and loss of energy. In laminar flow the shear stress between adjacent layers parallel to the direction of flow is proportional to the velocity gradient. Thus shear stress

$$s_s = \text{constant}\ \frac{dV}{dy} = \mu\frac{dV}{dy}$$

where, V = velocity, y = distance normal to flow, and μ = dynamic viscosity

Force to move flat plate over fixed plate of area A (Fig. 1.4)

$$F = s_s A = \mu A\ \frac{V}{y}$$

$$\text{Kinematic viscosity, } \nu = \frac{\text{Dynamic viscosity } (\mu)}{\text{Density } (\rho)}$$

Dynamic viscosity: $ML^{-1}T^{-1}$ (Ns/m^2), Kinematic viscosity: L^2T^{-1} (m^2/s)

Viscosity of water at room temperature is

$$\mu = 10^{-3}\ \text{Nsm}^{-2}, \text{ and } \nu = 10^{-6}\ \text{m}^2\text{s}^{-1}$$

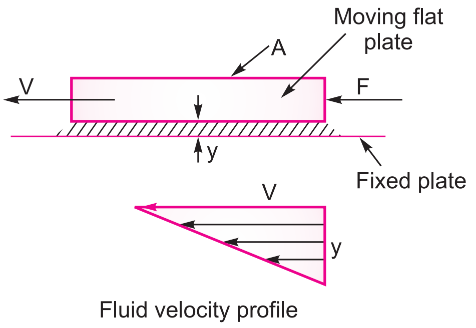


Fig. 1.4

For laminar flow in circular pipes, flow $Q = \pi\dfrac{(p_1 - p_2)r^4}{8\mu L}$, and mean velocity $V = \dfrac{(p_1 - p_2)r^2}{8\mu L}$, and maximum velocity $V_m = 2V$.

For laminar flow between flat plates, flow

$$Q = \frac{(p_1 - p_2)wt^3}{12\mu L}, \text{ mean velocity } V = \frac{(p_1 - p_2)t^2}{12\mu L}, \text{ and}$$

maximum velocity $V_m = \frac{3}{2}V$.

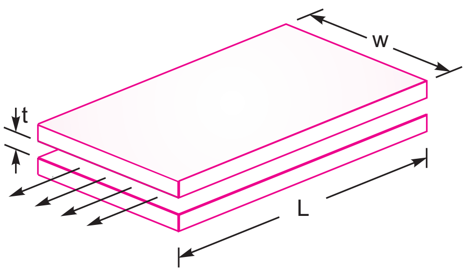


Fig. 1.5

For flow through annulus (small gap), (Fig. 1.5)

$$Q = \frac{\pi}{8\mu L}(p_1 - p_2)(R^2 - r^2)\left[(R^2 + r^2) - \frac{(R^2 - r^2)}{\ln\dfrac{R}{r}}\right]$$

and mean velocity $V = \dfrac{Q}{\pi(R^2 - r^2)}$

In turbulent flow (most prevalent in engineering practice) the fluid particles move in very irregular paths. It sets up greater shear stresses throughout the fluid and causes more irreversibilities or losses which are proportional to square of velocity.

According to continuity equation

$$\rho_1 v_1 A_1 = \rho_2 v_2 A_2$$

ρ = density, v = velocity, A = Area

According to Bernoulli's theorem

$$\frac{v_1^2}{2g} + \frac{p_1}{w_1} + Z_1 = \frac{v_2^2}{2g} + \frac{p_2}{w_2} + Z_2 + \text{Losses}$$

(p = pressure, w = sp. wt., Z = elevation)

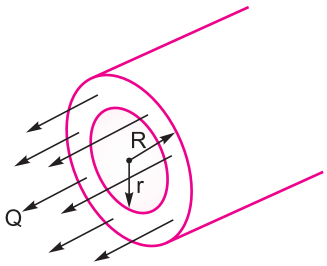


Fig. 1.6

For pipes in series, the pressure loss is the sum of the individual losses:

Pressure loss $p_f = p_{f1} + p_{f2} + \ldots$

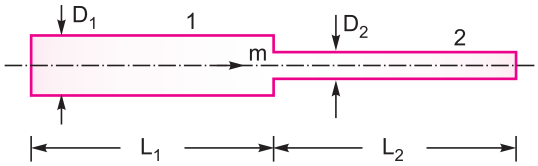


Fig. 1.7

The mass flow rate is the same in all pipes, *i.e.*

$$\dot{m} = \dot{m}_1 = \dot{m}_2 = \text{etc.}$$

where, $\dot{m}_1 = \rho A_1 v_1$, etc. kgs^{-1}

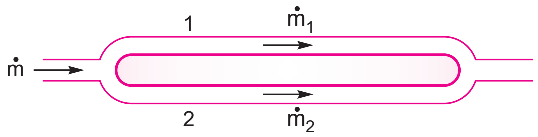
For pipes in parallel, the pressure loss is the same in all pipes:

Pressure loss $p_f = p_{f1} = p_{f2}$ = etc.

The total flow is the sum of the flow in each pipe:

Total flow $\quad \dot{m} = \dot{m}_1 + \dot{m}_2 + \ldots$

where, $p_{f1} = 4f_1 \dfrac{L_1}{D_1} \rho \dfrac{v_1^2}{2}$, $p_{f2} = 4f_2 \dfrac{L_2}{D_2} \rho \dfrac{v_2^2}{2}$, etc.



Head **loss due to pipe enlargement**

$$= K_e \frac{V_1^2 - V_2^2}{2g}$$

where, value of $K_e = 0.39$ for $\alpha = 10°$,

1.06, for $\alpha = 40°$ and 1.0 for 30° (Fig. 1.3)

In **open channel flow, hydraulic radius**

$$= \frac{\text{Water cross-sectional area}}{\text{Wetted perimeter}}$$

Weirs, Vee notch and channels. For unsuppressed weir, [Fig. 1.8 (*a*)], Flow $Q = 2.95 C_d (b - 0.2H) H^{1.5}$

For suppressed weir, [Fig. 1.8 (*b*)], Flow $Q = 3.33\, bH^{1.5}$

For V-notch [Fig. 1.8 (*c*)], flow $Q = 2.36\, C_d \tan \dfrac{\theta}{2} H^{2.5}$

where, C_d = discharge coefficient

For open channels, [Fig. 1.8 (*d*)], Mean velocity $V = C\sqrt{mi}$ and flow rate $Q = VA$

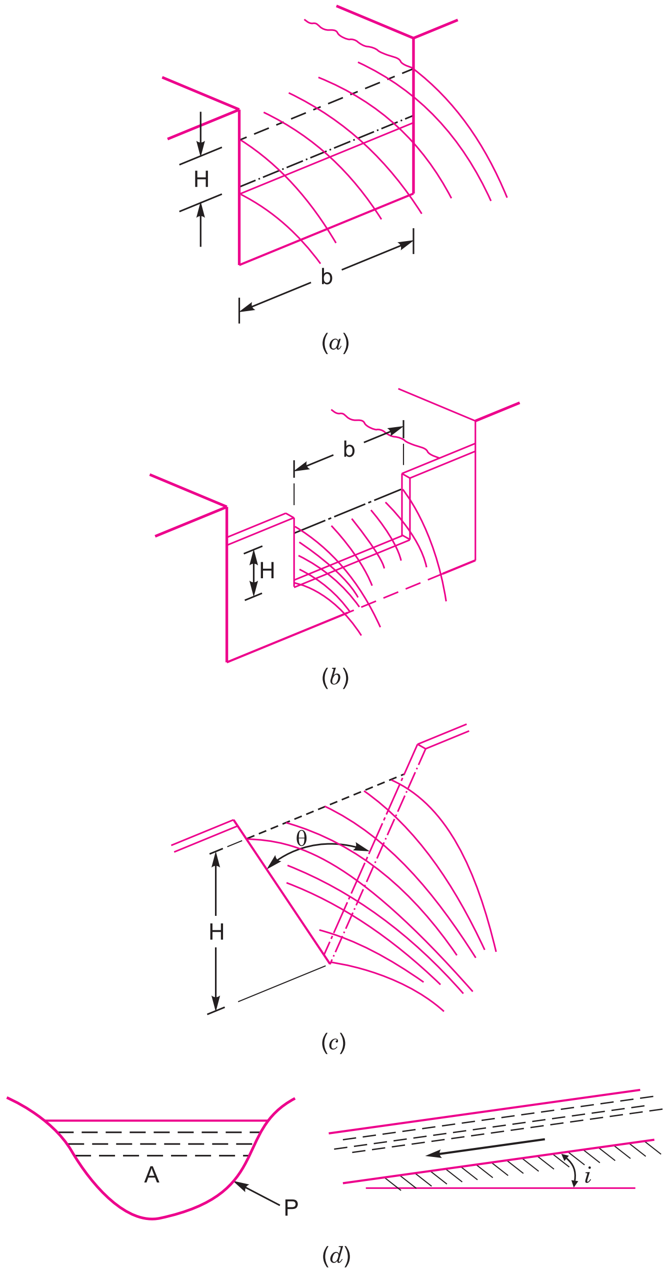


Fig. 1.8

m = hydraulic mean radius = A/P

i = slope of channel

C = constant = $87/[1 + (K/\sqrt{m})]$

Value of K is 0.16 to 0.28 for brick and stone surface, and 1.30 for natural earth.

A = flow area

P = wetted perimeter

Best hydraulic section is one with the least wetted perimeter.

The best hydraulic trapezoidal section is a half-hexagon.

Hydraulic jump in an open channel is an abrupt reduction in flow velocity by means of a sudden increase of water depth in the downstream direction.

Hydraulic jump occurs when a rapidly flowing stream of liquid in an open channel suddenly changes to a slowly flowing stream with a larger cross-sectional area and a sudden rise in elevation of liquid surface occurs. This is the example of steady non-uniform flow. It is very effective device for creating irreversibilities and is commonly used at the end of chutes or the bottom of spillways to destroy much of kinetic energy in flow.

Any obstruction of a stream flow over which water flows can be called a **weir.**

If the downstream water level rises over the weir crest, the weir is said to be submerged.

A **spillway** is an essential part of a large dam and provides an efficient, safe means of releasing flow water that exceeds the design capacity of the reservoir.

Culverts are built at the point of lowest valley to pass water across the embarkments of highways or railroads.

Standpipe is used principally for alleviating the transient pressure in large pipe line systems. It acts as a pressure relief valve for the upstream pipe during the turbine shut off. Water hammer effects are also diminished noticeably.

Dimensional analysis. The analysis of the basic relationship of the various physical quantities, involved in the static and dynamic behaviours of water flow in a hydraulic structure is known as *dimensional analysis.*

Similarity between hydraulic models and prototype may be achieved in three basic forms:

(*i*) *Geometric similarity* implying similarity of form.

(*ii*) *Kinematic similarity* implying similarity in motion.

(*iii*) *Dynamic similarity* implying similarity in forces involved in motion.

Dimensionless parameters permit limited experimental results carried in laboratories to be applied to actual big size objects in fluids of different properties. The five most important parameters used in correlating experimental data are:

(*i*) *Pressure coefficient*

$$= \frac{\Delta p}{\frac{\rho v^2}{2}} = \frac{\text{Pressure}}{\text{Dynamic pressure}} = \frac{\Delta p \times A}{\frac{\rho v^2 A}{2}} = \frac{\text{Pressure force}}{\text{Inertial force}}$$

$$= \frac{\frac{\Delta p}{\rho g}}{\frac{v^2}{2g}} = \frac{\frac{\Delta p}{\text{sp. wt.}}}{\frac{v^2}{2g}} = \frac{\Delta h}{\frac{v^2}{2g}}$$

For pipe flow the Darcy-Weisbach equation relates losses h_1 to length of pipe L, diameter D, and velocity v by a dimensionless friction factor f

$$h_1 = f\,\frac{L}{D}\,\frac{v^2}{2g} \quad \text{or} \quad \frac{h_1}{v^2/2g} = \frac{fL}{D}$$

(*ii*) *Reynolds number :*

$$= \frac{\rho v D}{\mu} = \frac{\text{Inertial force}}{\text{Viscous force}}$$

A critical Reynolds number is the demarcation between laminar and turbulent flow in pipe.

(*iii*) *Froude number :*

$$= \frac{v^2}{gl} = \frac{v^2 \rho A}{gl\rho A} = \frac{\text{Dynamic force}}{\text{Weight}}$$

Froude number decides whether the free liquid-surface flow is rapid or tranquil depending on whether Froude number is greater or less than unity. It is useful in calculations of hydraulic jump, in design of hydraulic structures, and in ship design.

(*iv*) *Weber number :*

$$= \frac{v^2 lp}{\sigma} = \frac{\text{Inertial force}}{\text{Surface-tension force}}$$

It is important at gas-liquid or liquid-liquid interfaces and also where these interfaces are in contact with a boundary.

(*v*) *Mach number* $= v/\sqrt{K/p}$

It is a measure of the ratio of inertial forces to elastic forces and is very important when velocities are near or above local sonic velocities. (K = bulk modulus of elasticity).

Model studies are big aid to the designer. These permit visual observation of flow and make possible the obtaining of certain numerical data and picture of behaviour of actual big size models by conducting tests on models in laboratories. For obtaining accurate quantitative data from model study, there must be dynamic similitude between model and prototype. For this purpose there must be exact (*i*) geometric similitude and (*ii*) kinematic simlitude *i.e.*, the ratio of dynamic pressure at corresponding points must be a constant. Geometric similitude refers to the actual surface roughness of the model and prototype. For dynamic pressures to be in the same ratio at corresponding points in model and prototype, the ratios of various types of forces must be the same at corresponding points.

For laminar flow through circular tubes and circular annuli,

$$\Delta p = \frac{128 \mu L Q}{\pi D^4}$$

where, μ = coefficient of viscosity, L = length, Q = flow rate, D = pipe diameter.

Also, head loss $h_1 = f\,\frac{4L}{D}\,\frac{v^2}{2g}$

Time for discharge from an orifice of area 'a' in a cylindrical vessel of cross-sectional area A to fall from height H_1 to H_2 is

$$t = \frac{2A}{C_d \, . \, a\sqrt{2g}} \left(\sqrt{H_1} - \sqrt{H_2}\right)$$

Similar time in case of two vessels of area A_1 and A_2 interconnected together

$$= \frac{2A_1 A_2 \left(\sqrt{H_1} - \sqrt{H_2}\right)}{(A_1 + A_2)\, C_d \, . \, a\sqrt{2g}}$$

Notch is a device used for measuring the rate of flow of a liquid through a small channel. A weir is a concrete or masonary structure placed in the open channel over which the flow occurs.

Flow over *rectangular/weir* or notch of length L and depth H is

$$Q = \frac{2}{3} C_d \sqrt{2g}\ L \,.\, H^{3/2}.$$

Flow over *triangular weir* or notch of semi-angle θ and water depth H is

$$Q = \frac{8}{15} C_d \sqrt{2g}\ \tan\theta\, H^{5/2}.$$

The error in discharge due to error in measurement of H for rectangular and triangular notch/weir is $\frac{dQ}{Q} = \frac{3}{2}\frac{dH}{H}$ and $\frac{5}{2}\frac{dH}{H}$ respectively.

Flow over broad crested weir of length L and water depth over weir before the weir H is

$$Q = 1.7\, C_d L \cdot H^{3/2}$$

Hydraulic gradient or hydraulic slope

$$= \frac{\text{Head lost due to friction}}{\text{Total length of pipe}}$$

Hydraulic mean depth or *hydraulic radius*

$$= \frac{\text{Area of cross-section } (A)}{\text{Total length of pipe}}$$

(surface in contact with water)

According to *Darcy equation*

$$h_f = \frac{f\,Pl}{A}\cdot\frac{v^2}{2g}; \text{ and for pipe this is}$$

$$h_f = \frac{4f\,l}{D}\cdot\frac{v^2}{2g}$$

According to *Chezy's formula*

$$v = \sqrt{mi}\,,\ C = \text{Chezy's constant.}$$

The *losses of head in pipes* are

(*i*) Loss at the entrance = $\frac{0.5\,v^2}{2g}$,

(*ii*) Loss at the outlet = $\frac{v^2}{2g}$

(*iii*) Loss due to friction = $\frac{4flv^2}{2g\cdot d}$

(*iv*) Total loss of head in a pipe flow

$$= \frac{0.5\,v^2}{2g} + \frac{v^2}{2g} + \frac{4flv^2}{2g\cdot d}$$

where, v is the velocity of flow, l is the length of pipe, d is diameter of pipe and f is fundamental resistance per unit area.

For maximum power transmitted by a nozzle, the head loss due to friction should be $\frac{1}{3}$rd of supply head.

For maximum power transmission by a nozzle, the diameter d may be obtained from the formula,

$$d = \left(\frac{D^5}{8fL}\right)^{1/4}$$

where, D = Diameter of main pipe,

L = length of the pipe, and

f = Darcy's coefficient of friction

Again, for maximum power transmission by a nozzle, the ratio of the area of the pipe to the area of the nozzle is related by

$$\frac{A}{a} = \sqrt{\frac{8fL}{D}}$$

The pipes of different diameters connected with one another to form a pipe line, is called a *compound pipe* or *pipes in series.*

$$\text{Total head loss} = \frac{fQ^2}{3}\left(\frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5} + \ldots + \frac{l_n}{d_n^5}\right)$$

where, $l_1, l_2, l_3, \ldots\, l_n$ are the lengths of individual portions and $d_1, d_2, d_3, \ldots, d_n$ are the diameters of the respective portions.

The pipe of uniform diameter which may replace a compound pipe, keeping the loss of head and discharge same, in both cases, is called *equivalent pipe*, and its diameter is called equivalent size of the pipe.

Let, $d_1, d_2, d_3, \ldots, d_n$ be the diameters

$l_1, l_2, l_3, \ldots, l_n$ be the length of various pipes

L and D, the length and diameter of the equivalent pipe

then
$$\frac{L}{D^5} = \frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5} + \ldots + \frac{l_n}{d_n^5}$$

For Laminar flow in a circular pipe, $\theta = \frac{\pi r_0^4}{8\mu}\left(\frac{p_1 - p_2}{L}\right)$

Water Hammer. Water hammer is caused due to sudden stoppage of water flow in a pipe. Sudden stoppage results in a pressure wave which moves upstream with velocity of sound in the medium which is reflected back and forth until dissipated by friction and imperfect elasticity.

Rise of pressure (p) due to sudden stopping of flow in a pipe

$$p = \frac{v}{\sqrt{\frac{g}{w}\left(\frac{1}{k} + \frac{D}{tE}\right)}}$$

where, v = velocity of flow in pipe of diameter D, thickness t and coefficient of elasticity E

K = coefficient of bulk modulus of fluid, and

w = specific weight of fluid.

Surge tanks are used to relieve the pipe line of excessive pressure.

Flow in Pipes

The following conditions must be satisfied in a network of pipes :

(*i*) The algebraic sum of the pressure drops around each circuit must be zero.

(*ii*) Flow into each junction must be equal flow out of the junction.

(*iii*) The Darcy equation must be satisfied for each pipe *i.e.* proper relation between head loss and discharge must be maintained for each pipe.

According to momentum equation, the net force acting on a fluid mass is equal to the change in momentum per second in that direction.

Isothermal flow in pipe (Refer Fig. 1.9 (*a*))

Pressure drop:

$$\Delta p = p_1 \left(1 - \sqrt{1 - \frac{8fLV_1^2}{2gDRT}}\right)$$

Mass flow $\dot{m} = \rho_1 V_1 \pi \frac{D^2}{4} = \frac{p_1}{RT} V_1 \pi \frac{D^2}{4}$.

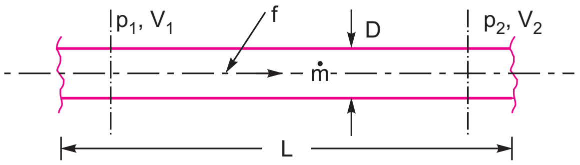


Fig. 1.9 (*a*)

Flow through orifice (Refer Fig. 1.9 (*b*))

$$\text{Mass flow } \dot{m} = C_d A \sqrt{2g\left(\frac{\gamma}{\gamma - 1}\right) p_1 \rho_1 n^2 \left(1 - n^{\frac{\gamma-1}{\gamma}}\right)}$$

where, $n = p_2/p_1$; $\rho_1 = p_1/RT_1$

$$\text{Maximum flow when } n = \left[\frac{2}{\gamma + 1}\right]^{\frac{\gamma}{\gamma - 1}} = 0.528 \text{ for air.}$$

where, $\gamma = c_p/c_v$,

R = gas constant, C_d = discharge coefficient

Drag $D = C_d A\rho \frac{V^2}{2}$; ρ = fluid density; A = frontal area; V = fluid velocity.

The drag coefficient (non-dimensional drag) is equal to the drag force divided by the product of velocity pressure and frontal area.

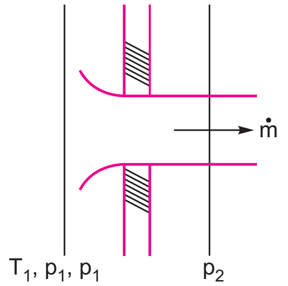


Fig. 1.9 (*b*)

Velocity of sound in a gas

$$V_s = \sqrt{\gamma p/\rho} = \sqrt{\gamma RT},$$

$$\text{Mach number } M = \frac{V}{V_s}$$

Kinematics of fluid motion

Streamline has differential equation $\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}$

For steady flow $a_t = v\, \partial v/\partial s$, and $a_n = v^2/r$

For unsteady flow $a_t = \partial v/\partial t + v\, \partial v/\partial s$, $a_n = \partial v_n/\delta t + v^2/r$

where, v = velocity tangent to stream line,

a_t = tangential acceleration and

a_n = normal acceleration,

r = radius of stream line, and

v_n = velocity normal to stream line.

Acceleration in two-dimensional flow

$$a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\ ;\ a_y = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}$$

In polar coordinates:

$$\text{Radial acceleration, } a_r = v_r\frac{\partial v_r}{\partial r} + v_\theta\frac{\partial v_r}{r\partial\theta} - \frac{v_\theta^2}{r},$$

$$\text{Tangential acceleration, } a_\theta = v_r\frac{\partial v_\theta}{\partial r} + v_\theta\frac{\partial v_\theta}{\partial\theta} + \frac{v_r v_\theta}{r}$$

where, $v_r = \frac{dr}{dt}$, $v_\theta = r\frac{d\theta}{dt}$

Acceleration in three-dimensional flow :

$$a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z},$$

$$a_y = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z},$$

$$a_z = \frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial u}{\partial z}$$

General equation of continuity with Cartesian coordinates (x, y, z)

$$\frac{\partial\rho}{\partial t} + u\frac{\partial\rho}{\partial x} + v\frac{\partial\rho}{\partial y} + w\frac{\partial\rho}{\partial z} + \rho\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) = 0$$

For incompressible fluid and steady motion

$$\text{For 3D flow, } \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

For two-dimensional flow, $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$, and for one-dimensional flow, $\frac{\partial u}{\partial x} = 0$

General equation of continuity with cylendrical coordinates (r, θ, z) is

$$\frac{\partial\rho}{\partial t} + \frac{1}{r}\frac{\partial}{\partial r}(\rho v_r \cdot r) + \frac{1}{r}\frac{\partial}{\partial\theta}(\rho\, v_\theta) + \frac{\partial}{\partial z}(\rho v_z) = 0$$

For incompressible fluid,

$$\frac{1}{r}\frac{\partial}{\partial r}(v_r \cdot r) + \frac{1}{r}\frac{\partial v_\theta}{\partial\theta} + \frac{\partial v_z}{\partial z} = 0$$

General equation of continuity with spherical coordinates (r, θ, ϕ)

$$\frac{\partial\rho}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(\rho v_r \cdot r^2) + \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(\rho v_\theta \sin\theta) + \frac{\partial}{\partial\phi}(\rho v_\phi)\right] = 0$$

For incompressible fluid,

$$\frac{1}{r^2}\frac{\partial}{\partial r}(v_r \cdot r^2) + \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial\theta}(v_\theta \sin\theta) + \frac{\partial v_\phi}{\partial\phi}\right] = 0$$

If the flow is axisymmetric, then

$$\frac{1}{r^2}\frac{\partial}{\partial r}(v_r \cdot r^2) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(v_\theta \sin\theta) = 0$$

Circulation, $\Gamma = \oint V . ds = \oint V \cos\theta \, ds = \oint (u\hat{i} + v\hat{j} + w\hat{k}).(dx\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}) = \oint (udx + vdy + wdz)$

where, $\oint$ = represents the line integral taken around the closed curve in anticlockwise direction.

V = total velocity ;

ds = elemental length,

θ = angle between V and ds.

Vorticity (ξ)

$$\xi_x = \frac{d\Gamma}{dydz} = \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z} ;$$

$$\xi_y = \frac{d\Gamma}{dzdx} = \frac{\partial u}{\partial z} - \frac{\partial w}{\partial z},$$

$$\xi_z = \frac{d\Gamma}{dxdy} = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$$

In polar coordinates,

$$\xi_z = \frac{v_\theta}{r} + \frac{\partial v_\theta}{\partial r} - \frac{1}{r}\frac{\partial v_r}{\partial\theta}$$

For a circular boundary, $\xi = 2\omega$, (ω = constant angular speed of rotation)

For an irrotational flow, $\xi = 0$.

Dynamics of Fluid Flow

Euler's equations of motion

$$\left.\begin{aligned}\frac{Du}{Dt} &= \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = X - \frac{1}{\rho}\frac{\partial p}{\partial x}\\ \frac{Dv}{Dt} &= \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = Y - \frac{1}{\rho}\frac{\partial p}{\partial y}\\ \frac{Dw}{Dt} &= \frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} = Z - \frac{1}{\rho}\frac{\partial p}{\partial z}\end{aligned}\right\}$$

$\frac{D}{Dt}$ = total derivative ; X, Y, Z = body forces per unit mass along x, y and z respectively.

Boundary Layer Flow

Nominal thickness,

$y = \delta$ for $u = 0.99\, U_\infty$

U_∞ = free stream velocity

Displacement thickness,

$$\delta^* = \int_0^\delta \left(1 - \frac{u}{U_\infty}\right) dy$$

Momentum thickness,

$$\theta = \int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right) dy$$

Relationship between the three thicknesses,

$$\delta = 3\delta^* = 7.5\,\theta$$

Energy thickness,

$$\delta_e = \int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u^2}{U_\infty^2}\right) dy$$

Loss of energy per unit time,

$$E_L = \frac{1}{2}\rho b \delta_e U_\infty^3$$

For laminar boundary layer,

$$\frac{\delta}{x} = \frac{5}{\sqrt{\text{Re}_x}}$$

where, $\text{Re}_x = \frac{U_\infty x}{v} < 5 \times 10^5$, b = width of flow section.

Turbulent boundary layer, $\frac{\delta}{x} = \frac{0.37}{\text{Re}_x^{1/5}}$

Refer Fig. 1.10 for boundary layer characteristics of a smooth flat plate.

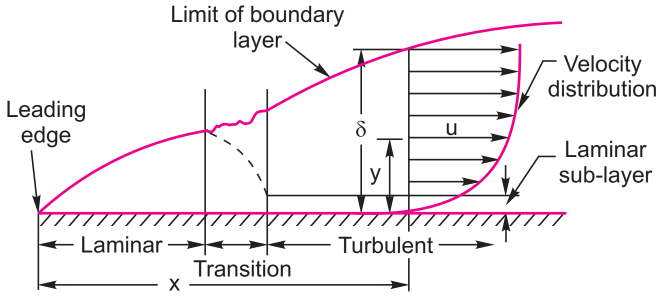


Fig. 1.10. Boundary layer on a smooth flat plate.

Prandtl's boundary layer equations :

$$\left.\begin{aligned}u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} &= U_\infty\frac{dU_\infty}{dx} + v\frac{\partial^2 u}{\partial y^2}\\ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} &= 0\end{aligned}\right\}$$

Momentum integral equation.

For two-dimensional incompressible laminar or turbulent boundary layer,

$$\frac{\tau_0}{\rho} = \frac{d}{dx}(U_\infty^2\,\theta) + \delta^* U_\infty\frac{dU_\infty}{dx}$$

For the x-direction,

$$\frac{d\theta}{dx} = \frac{1}{\rho U_\infty^2}\left[\tau_0 - (2\theta + \delta^*)\frac{dp}{dx}\right]$$

where, τ_0 = shear stress at the solid boundary

Pressure distribution $U_\infty\frac{dU_\infty}{dx} = -\frac{1}{\rho}\frac{dp}{dx}$

Laminar Flow

(*i*) Steady flow through a circular tube (Fig. 1.11)

Velocity profile, $u = -\frac{1}{4\mu}\left(\frac{dp}{dx}\right)(R_0^2 - r^2)$

$$u_{max.} = -\frac{1}{4\mu}\left(\frac{dp}{dx}\right)R_0^2$$

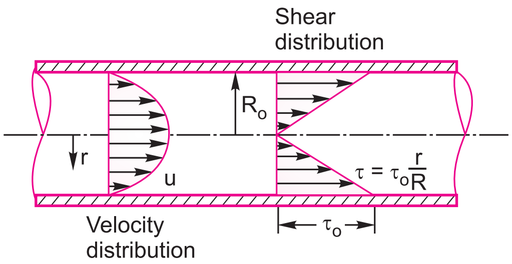


Fig. 1.11. Steady flow through a circular tube.

Fluid flow rate,

$$Q = \frac{1}{8\mu}\left(-\frac{dp}{dx}\right)\pi R_0^4 = \frac{\pi d^4 \,.\, \Delta p}{128\mu L}$$

(Hagen-Poiseuille equation),

$d = 2R_0$, Δp = pressure drop.

Shear stress at pipe wall,

$$\tau_0 = \left(\frac{\Delta p}{L}\right)\frac{R_0}{2}$$

Average velocity through tube,

$$\bar{v} = \frac{Q}{\pi R_0^2} = \frac{\Delta p\, R_0^2}{8\mu L}$$

Pressure drop,

$$\Delta p = \frac{8\mu \bar{v}\, L}{R_0^2} = \frac{32\mu \bar{v}\, L}{d^2}$$

Energy loss per unit weight of fluid,

$$\frac{\Delta p}{\gamma} = \frac{32\mu\, \bar{v}\, L}{\rho g d^2} = \frac{64}{\text{Re}} \cdot \frac{L}{d} \cdot \frac{\bar{v}^2}{2g}$$

Head loss, $h_l = f \,.\, \frac{L}{d} \cdot \frac{\bar{v}^2}{2g}$, Friction factor, $f = \frac{64}{\text{Re}}$, where

Reynold's number, $\text{Re} = \frac{\bar{v} d}{\nu}$

Stokes Law

Force resisting the motion of a sphere through a viscous fluid,

$$F_p = 3\pi\mu v d$$

where, v = velocity of sphere relative to undisturbed fluid,

μ = dynamic viscosity of fluid,

d = diameter of sphere

Terminal velocity, $v = \frac{d^2}{18\mu}(w_s - w_l)$

w_s = specific weight of sphere ;

w_l = specific weight of liquid

Drag and Lift

Drag, $F_D = \int pdA \sin\theta$, Lift, $F_L = \int pdA \cos\theta$

where, θ = angle between elementary area dA and flow direction.

Pressure drag, $F_{Dp} = \int pdA$,

Drag coefficient, $C_D = \frac{F_D}{\frac{1}{2}\rho U_\infty^2 A}$,

Lift coefficient, $C_L = \frac{F_L}{\frac{1}{2}\rho U_\infty^2 A}$

(u_∞ = free stream velocity)

Laminar Boundary Layer Over a Flat Plate

Boundary layer thickness,

$$\delta = \frac{5x}{\sqrt{\text{Re}_x}} \text{ at } \frac{u}{U_\infty} = 0.992$$

Displacement thickness, $\delta = \frac{1.73x}{\sqrt{\text{Re}_x}}$,

Momentum thickness, $\theta = \frac{0.664x}{\sqrt{\text{Re}_x}}$

Local wall shear, $\tau_0 = \frac{0.332}{\sqrt{re_x}} . \rho\, U_\infty^2$

where, $\text{Re}_x = \frac{U_\infty x}{v}$, x = distance from leading edge

Local friction drag coefficient,

$$C_f = \frac{\tau_0}{\frac{1}{2}\rho U_\infty^2} = \frac{0.664}{\sqrt{\text{Re}_x}}$$

Friction drag over one side of the plate of length L per unit width, $F_{Df} = 0.664\, \rho\, U_\infty^2 \sqrt{vL/U_\infty}$

Average friction drag coefficient,

$$\overline{C_f} = \frac{F_{Df}}{\frac{1}{2}\rho U_\infty^2 L} = \frac{1.328}{\sqrt{\text{Re}_L}}, \text{ where, } \text{Re}_L = \frac{U_\infty L}{v}$$

Turbulent Boundary Layer over a Smooth Flat Plate

Blasius one-seventh power law,

$$\frac{u}{U_\infty} = \left(\frac{y}{\delta}\right)^{1/7} \text{ for } \text{Re}_L < 10^6$$

Average velocity,

$$\bar{v} = 0.817\, U_{max} = 0.817\, U_\infty$$

Wall shear stress,

$$\tau_0 = 0.0233\, \rho_2\, U_\infty^2 \left(\frac{U_\infty \delta}{v}\right)^{-1/4} = 0.0295\, \rho\, U_\infty^2\, (\text{Re}_x)^{-1/5}$$

Boundary layer thickness, $\delta = \frac{0.379\, x}{(\text{Re}_x)^{1/5}} \propto x^{4/5}$

Local skin friction coefficient $C_f = \frac{0.059}{\text{Re}_x^{1/5}}$

Friction drag per unit width for one side of plate of length L,

$$F_{Df} = 0.0368\, L\, \rho\, U_\infty^2\, \text{Re}_L^{-1/5}$$

Average coefficient of friction drag,

$$\overline{C_f} = \frac{0.074}{\text{Re}_L^{1/5}} \text{ for } 5 \times 10^5 < \text{Re}_L < 10^7$$

$$= \frac{0.455}{(\log_{10} \text{Re}_L)^{258}} \text{ for } 10^6 < \text{Re}_L < 10^9$$

Simultaneous Laminar and Turbulent Boundary Layers on a Flat Plate

$$\frac{(\bar{C}_f)_{lam}}{(\bar{C}_f)_{turb}} = \frac{17.81}{Re_L^{3/10}} = 0.35 \text{ for } Re_L = 5 \times 10^5$$

Total friction drag

$$F_{Df} = \left[\frac{0.074}{Re_L^{1/5}} - \frac{1700}{Re_L}\right]\left(\frac{1}{2}\rho U_\infty^2 L\right)$$

$$\bar{C}_f = \frac{0.074}{Re_L^{1/5}} - \frac{1700}{Re_L} \text{ for } Re_L = 5 \times 10^5 \text{ to } 10^7$$

Flow Past a Sphere

Deformation drag, $F_D = 3\pi\mu\, U_\infty < d$

Drag coefficient,

$$C_D = \frac{24}{R_e} \text{ for } R_e\, 0.1$$

$$C_D = \frac{24}{R_e}\left(1 + \frac{3}{16}Re\right) \text{ for } R_e < 1.0$$

$$C_D = \frac{24}{R_e}\left(1 + \frac{3}{16}Re\right)^{1/3} \text{ for } R_e \text{ upto } 100.$$

Pressure distribution for an ideal fluid

$$\frac{p - p_\infty}{\frac{1}{2}\rho U_\infty^2} = 1 - \frac{9}{4}\sin^2\theta$$

where, θ = angle measured anti-clockwise from the downstream stagnation point.

Steady State Heat Conduction

(*a*) One-dimensional system:

General Fourier equation of heat conduction.

As per Cartesian coordinates, $\frac{d^2T}{dx^2} = 0.$

As per cylindrical coordinates, $\frac{d^2T}{dr^2} + \frac{1}{r}\frac{dT}{dr} = 0.$

and as per spherical coordinates, $\frac{d^2T}{dr^2} + \frac{2}{r}\frac{dT}{dr} = 0.$

Heat transfer rates

$$q = -kA\frac{dT}{dx}, \quad \text{or} \quad q = -kA\frac{dT}{dr}$$

(*b*) Two-dimensional systems, $\nabla^2 T = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$

(Laplace equation)

Its general solution is

$$T = (C_1 \sin\lambda x + C_2 \cos\lambda x)(C_3 e^{\lambda y} + C_4 e^{-\lambda y})$$

where λ = eigen value and C_1, C_2, C_3 and C_4 are constants.

Extended Surfaces

Differential equation of heat transfer is

$$\frac{d^2T}{\partial x^2} - m^2 T = -m^2 T_\infty$$

where, $m^2 = \frac{h_c P}{kA}$, P = perimeter

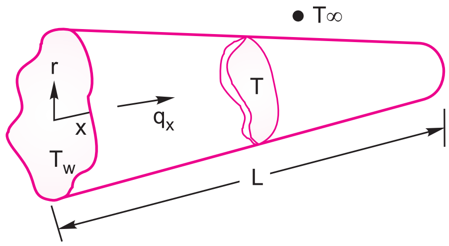


Fig. 1.12. Extended surface.

General solution of above equation is

$$T - T_\infty = C_1 e^{mx} + C_2 e^{-mx}$$

$$\frac{q_{\text{without fin}}}{q_{\text{fin}}} \equiv \sqrt{\frac{h_c A}{kP}}$$

Fin efficiency,

$$\eta_e = \frac{\tan h(mL)}{mL} \text{ for pin fin}$$

and

$$\eta_e = \frac{\tan h(mL) + \left(\frac{h_c}{mk}\right)}{mL\left[1 + \left(\frac{h_c}{mK}\right)\tan h(mL)\right]}$$

for rectangular fin

Fin effectiveness,

$$\eta_f = \frac{\text{Heat flux from wall after adding fin}}{\text{Heat flux from wall without fin}}$$

$$= \frac{q_x}{h_c A(T_\omega - T_\infty)}$$

$$\eta_f = \sqrt{\frac{kP}{h_c A}} \tan h\,(mL) \text{ for pin fin and}$$

$$n_f = \sqrt{\frac{kP}{h_c A}}\, \frac{\tan h(mL) + \left(\frac{h_c}{mk}\right)}{1 + \left(\frac{h_c}{mk}\right)\tan h(mL)} \text{ for rectangular fin}$$

If $\left(\frac{h_c A}{kP}\right) < 1$ fin provides cooling effect.

Unsteady Heat Conduction

(*a*) Bodies of infinitely high thermal conductivity ($k \to \infty$)

Governing equation : $\rho CV \frac{dT}{dt} = h_c A(T_f - T)$

Solution of this equation is $\frac{T - T_f}{T_0 - T_f} = e^{-(h_\tau A/\rho CV)t}$

where, T_f = fluid temperature,

T_0 = initial body temperature,

T = temperature at any time,

C = specific heat of the material, J/(kg. K),

ρ = material density, kg/m^3,

A = surface area, m^2,

V = volume of material, m^3.

(*b*) Bodies with negligible convective resistance.

Governing equation of heat transfer is,

$$\frac{1}{\alpha}\frac{\partial T}{\partial t} = \nabla^2 T,\ \nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

For one-dimensional heat flow system,

In Cartesian coordinates, $\frac{1}{\alpha}\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial x^2}$

In cylindrical coordinates, $\frac{1}{\alpha}\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r}$

In spherical coordinates, $\frac{1}{\alpha}\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial r^2} + \frac{2}{r}\frac{\partial T}{\partial r}$

MULTIPLE CHOICE QUESTIONS

1. Fluid is a substance that
(*a*) cannot be subjected to shear forces
(*b*) always expands until it fills any container
(*c*) has the same shear stress at a point regardless of its motion
(*d*) cannot remain at rest under action of any shear force
(*e*) flows.

2. Fluid is a substance which offers no resistance to change of
(*a*) pressure (*b*) flow
(*c*) shape (*d*) volume
(*e*) temperature.

3. Practical fluids
(*a*) are viscous
(*b*) possess surface tension
(*c*) are compressible
(*d*) possess all the above properties
(*e*) possess none of the above properties.

4. In a static fluid
(*a*) resistance to shear stress is small
(*b*) fluid pressure is zero
(*c*) linear deformation is small
(*d*) only normal stresses can exist
(*e*) viscosity is nil.

5. A fluid is said to be ideal, if it is
(*a*) incompressible (*b*) inviscous
(*c*) viscous and incompressible
(*d*) inviscous and compressible
(*e*) inviscous and incompressible.

6. An ideal flow of any fluid must fulfill the following
(*a*) Newton's law of motion
(*b*) Newton's law of viscosity
(*c*) Pascal' law
(*d*) Continuity equation
(*e*) Boundary layer theory.

7. If no resistance is encountered by displacement, such a substance is known as
(*a*) fluid (*b*) water
(*c*) gas (*d*) perfect solid
(*e*) ideal fluid.

The volumetric change of the fluid caused by a resistance is known as
(*a*) volumetric strain (*b*) volumetric index
(*c*) compressibility (*d*) adhesion
(*e*) cohesion.

9. Liquids
(*a*) cannot be compressed
(*b*) occupy definite volume
(*c*) are not affected by change in pressure and temperature
(*d*) are not viscous
(*e*) none of the above.

10. Density of water is maximum at
(*a*) 0°C (*b*) 0°K
(*c*) 4°C (*d*) 100°C
(*e*) 20°C.

11. Mass density of liquid (ρ) is given by
(*a*) $\rho = \frac{\text{Mass}}{\text{Volume}}$ (*b*) $\rho = \frac{\text{Metric}}{\text{m}^2}$
(*c*) $\rho = \frac{\text{kg sec}^2}{\text{m}^4}$ (*d*) all of the above
(*e*) none of the above.

12. The value of mass density in kg sec^2/m^4 for water at 0°C is
(*a*) 1 (*b*) 1000
(*c*) 100 (*d*) 101.9
(*e*) 98.1

13. Units of mass density is
(*a*) kg/km (*b*) kg/m^3
(*c*) $\frac{\text{kg sec}}{\text{m}^4}$ (*d*) $\frac{\text{kg sec}^2}{\text{m}^2}$
(*e*) $\frac{\text{kg sec}^2}{\text{m}^4}$.

14. Property of a fluid by which its own molecules are attracted is called
(*a*) adhesion (*b*) cohesion
(*c*) viscosity (*d*) compressibility
(*e*) surface tension.

15. Mercury does not wet glass. This is due to property of liquid known as
(*a*) adhesion (*b*) cohesion
(*c*) surface tension (*d*) viscosity
(*e*) compressibility.

16. The property of a fluid which enables it to resist tensile stress is known as
(*a*) compressibility (*b*) surface tension
(*c*) cohesion (*d*) adhesion
(*e*) viscosity.

17. Property of a fluid by which molecules of different kinds of fluids are attracted to each other is called
(*a*) adhesion (*b*) cohesion
(*c*) viscosity (*d*) compressibility
(*e*) surface tension.

18. The specific weight of water is 1000 kg/m^3
(*a*) at normal pressure of 760 mm
(*b*) at 4°C temperature (*c*) at mean sea level
(*d*) all the above (*e*) none of the above.

19. Specific weight of water in S.I. units is equal to
(*a*) 1000 N/m^3 (*b*) 10000 N/m^3
(*c*) 9.81×10^3 N/m^3 (*d*) 9.81×10^6 N/m^3
(*e*) 9.81 N/m^3.

20. When the flow parameters at any given instant remain same at every point, then flow is said
(*a*) quasi static (*b*) steady state
(*c*) laminar (*d*) uniform
(*e*) static.

21. Which of the following is dimensionless ?
(*a*) specific weight (*b*) specific volume
(*c*) specific speed (*d*) specific gravity
(*e*) specific viscosity.

22. The normal stress in a fluid will be constant in all directions at a point only if
(*a*) it is incompressible
(*b*) it has uniform viscosity
(*c*) it has zero viscosity
(*d*) it is frictionless
(*e*) it is at rest.

23. The pressure at a point in a fluid will not be same in all the directions when the fluid is
(*a*) moving (*b*) viscous
(*c*) viscous and static (*d*) inviscous and moving
(*e*) viscous and moving.

24. An object having 10 kg mass weights 9.81 kg on a spring balance. The value of 'g' at this place is
(*a*) 10 m/sec^2 (*b*) 9.81 m/sec^2
(*c*) 10.2/m sec (*d*) 9.75 m/sec^2
(*e*) 9 m/sec^2.

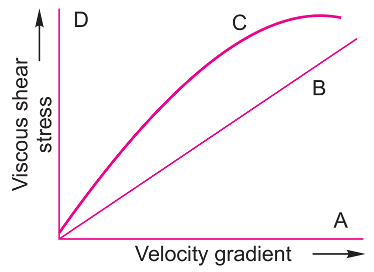
25. The tendency of a liquid surface to contract is due to the following property
(*a*) cohesion (*b*) adhesion
(*c*) viscosity (*d*) surface tension
(e) elasticity.

26. The surface tension of mercury at normal temperature compared to that of water is
(*a*) more (*b*) less
(*c*) same
(*d*) more or less depending on size of glass tube
(*e*) none of the above.

27. A perfect gas
(*a*) has constant viscosity
(*b*) has zero viscosity
(*c*) is incompressible
(*d*) is of theoretical interest
(*e*) none of the above.

28. For very great pressures, viscosity of most gases and liquids
(*a*) remains same (*b*) increases
(*c*) decreases
(*d*) shows erratic behaviour
(*e*) none of the above.

29. Fig. below shows four curves *A, B, C, D* on a plot of viscous shear stress versus velocity gradient for three fluids, viz., newtonian, non-newtonian and ideal; and an ideal solid. For ideal solid, the curve applicable is



(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) none of the above.

30. In above Fig., for ideal fluid, curve applicable is
(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) none of the above.

31. In above Fig., for Newtonian fluid, curve applicable is
(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) none of the above.

32. In above Fig., for non-Newtonian fluid, curve applicable is
(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) none of the above.

33. A fluid in equilibrium can't sustain
(*a*) tensile stress (*b*) compressive stress
(*c*) shear stress (*d*) bending stress
(*e*) all of the above.

34. Viscosity of water in comparison to mercury is
(*a*) higher (*b*) lower
(*c*) same
(*d*) higher/lower depending on temperature
(*e*) unpredictable.

35. The bulk modulus of elasticity with increase in pressure
(*a*) increases (*b*) decreases
(*c*) remains constant

(*d*) increases first upto certain limit and then decreases
(*e*) unpredictable.

8.36. The bulk modulus of elasticity
(*a*) has the dimensions of 1/pressure
(*b*) increases with pressure
(*c*) is large when fluid is more compressible
(*d*) is independent of pressure and viscosity
(*e*) is directly proportional to flow.

37. A balloon lifting in air follows the following principle
(*a*) law of gravitation (*b*) Archimedes principle
(*c*) principle of buoyancy (*d*) all of the above
(*e*) continuity equation.

38. The value of the coefficient of compressibility for water at ordinary pressure and temperature in kg/cm^3 is equal to
(*a*) 1000 (*b*) 2100
(*c*) 2700 (*d*) 10,000
(*e*) 21,000.

39. The increase of temperature results in
(*a*) increase in viscosity of gas
(*b*) increase in viscosity of liquid
(*c*) decrease in viscosity of gas
(*d*) decrease in viscosity of liquid
(*e*) (*a*) and (*d*) above.

40. Surface tension has the units of
(*a*) Newtons/m^2 (*b*) Newtons/m^2
(*c*) New tons/m (*d*) Newtons
(*e*) Newton m.

41. Surface tension
(*a*) acts in the plane of the interface normal to any line in the surface
(*b*) is also known as capillarity
(*c*) is a function of the curvature of the interface
(*d*) decreases with fall in temperature
(*e*) has no units.

42. The stress-strain relation of the Newtoneon fluid is
(*a*) linear (*b*) parabolic
(*c*) hyperbolic (*d*) inverse type
(*e*) none of the above.

43. A liquid compressed in cylinder has a volume of 0.04 m^3 at 50 kg/cm^2 and a volume of 0.039 m^3 at 150 kg/cm^2. The bulk modulus of elasticity of liquid is
(*a*) 400 kg/cm^2 (*b*) 4000 kg/cm^2
(*c*) 40 $\times 10^5$ kg/cm^2 (*d*) 40 $\times 10^6$ kg/cm^2
(*e*) none of the above.

44. The units of viscosity are
(*a*) metres^2 per sec (*b*) kg sec/metre^2
(*c*) Newton-sec per metre^2
(*d*) Newton-sec^2 per metre
(*e*) None of the above.

45. Kinematic viscosity is dependent upon
(*a*) pressure (*b*) distance
(*c*) level (*d*) flow
(*e*) density.

46. Units of surface tension are
(*a*) energy/unit area (*b*) distance
(*c*) both of the above (*d*) it has no units
(*e*) none of the above.

47. Which of the following meters is not associated with viscosity ?
(*a*) Red wood (*b*) Say bolt
(*c*) Engler (*d*) Orsat
(*e*) none of the above.

48. Choose the correct relationship
(*a*) specific gravity = gravity × density
(*b*) dynamic viscosity = kinematic viscosity × density
(*c*) gravity = specific gravity × density
(*d*) kinematic viscosity = dynamic viscosity × density
(*e*) hydrostatic force = surface tension × gravity.

49. Dimensions of surface tension are
(*a*) $M^1L^0T^{-2}$ (*b*) $M^1L^0T^{-1}$
(*c*) $M^1L^1T^{-2}$ (*d*) $M^1L^2T^{-2}$
(*e*) $M^1L^0T^1$.

50. For manometer, a better liquid combination is one having
(*a*) higher surface tension
(*b*) lower surface tension
(*c*) surface tension is no criterion
(*d*) high density and viscosity
(*e*) low density and viscosity.

51. If mercury in a barometer is replaced by water, the height of 3.75 cm of mercury will be following cm of water
(*a*) 51 cm (*b*) 50 cm
(*c*) 52 cm (*d*) 52.2 cm
(*e*) 51.7 cm.

52. Choose the wrong statement.
Alcohol is used in manometer, because
(*a*) its vapour pressure is low
(*b*) it provides suitable meniscus for the inclined tube
(*c*) its density is less
(*d*) it provides longer length for a given pressure difference
(*e*) it provides accurate readings.

53. Increase in pressure at the outer edge of a drum of radius R due to rotation at ω rad/sec, full of liquid of density ρ will be
(*a*) $\rho\omega^2R^2$ (*b*) $\rho\omega^2R^2/2$
(*c*) $2\rho\omega^2R^2$ (*d*) $\rho\omega^2R/2$
(*e*) none of the above.

54. The property of fluid by virtue of which it offers resistance to shear is called
(*a*) surface tension (*b*) adhesion
(*c*) cohesion (*d*) viscosity
(*e*) all of the above.

55. Choose the wrong statement
(*a*) fluids are capable of flowing
(*b*) fluids conform to the shape of the containing vessels

(*c*) when in equilibrium, fluids cannot sustain tangential forces
(*d*) when in equilibrium, fluids can sustain shear forces
(*e*) fluids have some degree of compressibility and offer little resistance to form.

56. The density of water is 1000 kg/m^3 at
(*a*) 0°C (*b*) 0°K
(*c*) 4°C (*d*) 20°C
(*e*) all temperature.

57. If w is the specific weight of liquid and h the depth of any point from the surface, then pressure intensity at that point will be
(*a*) h (*b*) wh
(*c*) w/h (*d*) h/w
(*e*) $1/wh$.

58. Choose the wrong statement
(*a*) Viscosity of a fluid is that property which determines the amount of its resistance to a shearing force
(*b*) Viscosity is due primarily to interaction between fluid molecules
(*c*) Viscosity of liquids decreases with increase in temperature
(*d*) Viscosity of liquids is appreciably affected by change in pressure
(*e*) Viscosity is expressed as poise, stoke, or saybolt seconds.

59. The units of kinematic viscosity are
(*a*) metres^2 per sec (*b*) kg sec/metre^2
(*c*) Newton-sec per metre^2
(*d*) Newton-sec^2 per metre
(*e*) none of the above.

60. The ratio of absolute viscosity to mass density is known as
(*a*) specific viscosity (*b*) viscosity index
(*c*) kinematic viscosity (*d*) coefficient of viscosity
(*e*) coefficient of compressibility.

61. Kinematic viscosity is equal to
(*a*) dynamic viscosity/density
(*b*) dynamic viscosity × density
(*c*) density/dynamic viscosity
(*d*) 1/dynamic viscosity × density
(*e*) same as dynamic viscosity.

62. Which of the following is the unit of kinematic viscosity ?
(*a*) Pascal (*b*) Poise
(*c*) Stoke (*d*) Faraday
(*e*) none of the above.

63. A one dimensional flow is one which
(*a*) is uniform flow (*b*) is steady uniform flow
(*c*) takes place in straight lines
(*d*) involves zero transverse component of flow
(*e*) takes place in one dimension.

64. Alcohol is used in manometers because
(*a*) it has low vapour pressure
(*b*) it is clearly visible
(*c*) it has low surface tension
(*d*) it can provide longer column due to low density
(*e*) is provides suitable meniscus.

65. A pressure of 25 m of head of water is equal to
(*a*) 25 kN/m^2 (*b*) 245 kN/m^2
(*c*) 2500 kN/m^2 (*d*) 2.5 kN/m^2
(*e*) 12.5 kN/m^2.

66. Specific weight of sea water is more that of pure water because it contains
(*a*) dissolved air (*b*) dissolved salt
(*c*) suspended matter (*d*) all of the above
(*e*) heavy water.

67. If 850 kg liquid occupies volume of 1 m^3, then 0.85 represents its
(*a*) specific weight (*b*) specific mass
(*c*) specific gravity (*d*) specific density
(*e*) none of the above.

68. $V = 0.0022\,t - \dfrac{1.8}{t}$, is the equation to determine kinematic viscosity of liquids by
(*a*) Redwood viscometer
(*b*) Engler viscometer
(*c*) Saybolt universal viscometer
(*d*) Newton viscometer
(*e*) none of the above.

69. Free surface of a liquid tends to contract to the smallest possible area due to force of
(*a*) surface tension (*b*) viscosity
(*c*) friction (*d*) cohesion
(*d*) adhesion.

70. A bucket of water is hanging from a spring balance. An iron piece is suspended into water without touching sides of bucket from another support. The spring balance reading will
(*a*) increase (*b*) decrease
(*c*) remain same
(*d*) increase/decrease depending on depth of immersion
(*e*) unpredictable.

71. Falling drops of water become spheres due to the property of
(*a*) adhesion (*b*) cohesion
(*c*) surface tension (*d*) viscosity
(*e*) compressibility.

72. A liquid would wet the solid, if adhesion forces as compared to cohesion forces are
(*a*) less (*b*) more
(*c*) equal
(*d*) less at low temperature and more at high temperature
(*e*) there is no such criterion.

73. If cohesion between molecules of a fluid is greater than adhesion between fluid and glass, then the free level of fluid in a dipped glass tube will be
(*a*) higher than the surface of liquid
(*b*) the same as the surface of liquid

(*c*) lower than the surface of liquid
(*d*) unpredictable (*e*) none of the above.

74. The point in the immersed body through which the resultant pressure of the liquid may be taken to act is known as
(*a*) meta centre (*b*) centre of pressure
(*c*) centre of buoyancy (*d*) centre of gravity
(*e*) none of the above.

75. The total pressure on the surface of a vertical sluice gate 2 m × 1 m, with its top 2 m surface being 0.5 m below the water level will be
(*a*) 500 kg (*b*) 1000 kg
(*c*) 1500 kg (*d*) 2000 kg
(*e*) 4000 kg.

76. The resultant upward pressure of a fluid on a floating body is equal to the weight of the fluid displaced by the body. This definition is according to
(*a*) Buoyancy
(*b*) Equilibrium of a floating body
(*c*) Archimedes' principle
(*d*) Bernoulli's theorem
(*e*) Metacentric principle.

77. The resultant upward pressure of the fluid on an immersed body is called
(*a*) upthrust (*b*) buoyancy
(*c*) centre of pressure
(*d*) all the above are correct
(*e*) none of above is correct.

78. The conditions for the stable equilibrium of a floating body are
(*a*) the meta-centre should lie above the centre of gravity
(*b*) the centre of buoyancy and the centre of gravity must lie on the same vertical line
(*c*) a righting couple should be formed
(*d*) all the above are correct
(*e*) none of the above is correct.

79. Poise is the unit of
(*a*) surface tension (*b*) capillarity
(*c*) viscosity (*d*) shear stress in fluids
(*e*) buoyancy.

80. Metacentric height is given as the distance between
(*a*) the centre of gravity of the body and the metacentre
(*b*) the centre of gravity of the body and the centre of buoyancy
(*c*) the centre of gravity of the body and the centre of pressure
(*d*) centre of buoyancy and metacentre
(*e*) none of the above.

81. The buoyancy depends on
(*a*) mass of liquid displaced
(*b*) viscosity of the liquid
(*c*) pressure of the liquid displaced
(*d*) depth of immersion
(*e*) none of the above.

82. The centre of gravity of the volume of the liquid displaced by an immersed body is called
(*a*) meta-centre (*b*) centre of pressure
(*c*) centre of buoyancy (*d*) centre of gravity
(*e*) none of the above.

83. A piece of metal of specific gravity 13.6 is placed in mercury of specific gravity 13.6, what fraction of it volume is under mercury?
(*a*) the metal piece will simply float over the mercury
(*b*) the metal piece will be immersed in mercury by half
(*c*) whole of the metal piece will be immersed with its top surface just at mercury level
(*d*) metal piece will sink to the bottom
(*e*) none of the above.

84. The angle of contact in case of a liquid depends upon
(*a*) the nature of the liquid and the solid
(*b*) the material which exists above the free surface of the liquid
(*c*) both of the above (*d*) any one of the above
(*e*) none of the above.

85. Free surface of a liquid behaves like a sheet and tends to contract to smallest possible area due to the
(*a*) force of adhesion (*b*) force of cohesion
(*c*) force of friction (*d*) force of diffusion
(*e*) none of the above.

86. Rain drops are spherical because of
(*a*) viscosity (*b*) air resistance
(*c*) surface tension forces (*d*) atmospheric pressure
(*e*) none of the above.

87. Surface energy per unit area of a surface is numerically equal to
(*a*) atmospheric pressure (*b*) surface tension
(*c*) force of adhesion (*d*) force of cohesion
(*e*) viscosity.

88. The capillary rise at 20°C in a clean glass tube of 1 mm bore containing water is approximately
(*a*) 1 mm (*b*) 5 mm
(*c*) 10 mm (*d*) 20 mm
(*e*) 30 mm.

89. The difference of pressure between the inside and outside of a liquid drop is
(*a*) $p = T \times r$ (*b*) $p = T/r$
(*c*) $p = T/2r$ (*d*) $p = 2T/r$
(*e*) none of the above.

90. If the surface of liquid is convex, then
(*a*) cohesion pressure is negligible
(*b*) cohesion pressure is decreased
(*c*) cohesion pressure is increased
(*d*) there is no cohesion pressure
(*e*) none of the above.

91. To avoid vaporisation in the pipe line, the pipe line over the ridge is laid such that it is not more than
(*a*) 2.4 m above the hydraulic gradient
(*b*) 6.4 m above the hydraulic gradient

(c) 10.0 m above the hydraulic gradient
(d) 5.0 above the hydraulic gradient
(e) none of the above.

92. To avoid an interruption in the flow of a syphon, an air vessel is provided
(a) at the inlet (b) at the outlet
(c) at the summit
(d) ay any point between inlet and outlet
(e) none of the above.

93. The vapour pressure over the concave surface is
(a) less than the vapour pressure over the plane surface
(b) equal to the vapour pressure over the plane surface
(c) greater than the vapour pressure over the plane surface
(d) zero (e) none of the above.

94. The property by virtue of which a liquid opposes relative motion between its different layers is called
(a) surface tension (b) co-efficient of viscosity
(c) viscosity (d) osmosis
(e) cohesion.

95. The process of diffusion of one liquid into the other through a semi-permeable membrane is called
(a) viscosity (b) osmosis
(c) surface tension (d) cohesion
(e) diffusivity.

96. The units of dynamic or absolute viscosity are
(a) metres^2 per sec (b) kg sec/metre
(c) Newton-sec per metre^2
(d) Newton-sec^2 per metre
(e) none of the above.

97. The dimensions of coefficient of viscosity are
(a) $M^1L^{-1}T^{-1}$ (b) $M^{-1}L^{-1}T^{-1}$
(c) $M^1L^1T^{-1}$ (d) $M^{-1}L^1T^1$
(e) $M^1L^{-1}T^1$.

98. The continuity equation is connected with
(a) viscous/unviscous fluids
(b) compressibility of fluids
(c) conservation of mass
(d) steady/unsteady flow
(e) open channel/pipe flow.

99. The rise or depression of liquid in a tube due to surface tension with increase in size of tube will
(a) increase
(b) remain unaffected
(c) may increase or decrease depending on the characteristics of liquid
(d) decrease
(e) unpredictable.

100. Liquids transmit pressure equally in all the directions. This is according to
(a) Boyle's law (b) Archimedes principle
(c) Pascal's law (d) Newton's formula
(e) Chezy's equation.

101. Capillary action is due to the
(a) surface tension (b) cohesion of the liquid
(c) adhesion of the liquid molecules and the molecules on the surface of a solid
(d) all of the above
(e) none of the above.

102. The rise or fall of head '*h*' in a capillary tube of diameter '*d*' and liquid surface tension 'σ' and specific weight '*w*' is equal to
(a) $\dfrac{4\sigma}{wd}$ (b) $\dfrac{4d\sigma}{w}$
(c) $\dfrac{4wd}{\sigma}$ (d) $\dfrac{4w\sigma}{d}$
(e) $\dfrac{4d}{w\sigma}$.

103. Newton's law of viscosity is a relationship between
(a) shear stress and the rate of angular distortion
(b) shear stress and viscosity
(c) shear stress, velocity and viscosity
(d) pressure, velocity and viscosity
(e) shear stress, pressure and rate of angular distortion.

104. The atmospheric pressure with rise in altitude decreases
(a) linearly
(b) first slowly and then steeply
(c) first steeply and then gradually
(d) unpredictable
(e) none of the above.

105. Pressure of the order of 10^{-10} torr can be measured by
(a) Bourdon tube (b) Pirani Gauge
(c) micro-manometer (d) ionisastion gauge
(e) McLeod gauge.

106. Operation of McLeod gauge used for low pressure measurement is based on the principle of
(a) Gas law (b) Boyle's law
(c) Charle's law (d) Pascal's law
(e) McLeod's law.

107. An odd shaped body weighing 7.5 kg and occupying 0.01 m^3 volume will be completely submerged in a fluid having specific gravity of
(a) 1 (b) 1.2
(c) 0.8 (d) 0.75
(e) 1.25.

108. In an isothermal atmosphere, the pressure
(a) decreases linearly with elevation
(b) remains constant
(c) varies in the same way as the density
(d) increases exponentially with elevation
(e) unpredictable.

109. Mercury is often used in barometer because
(a) it is the best liquid
(b) the height of barometer will be less
(c) its vapour pressure is so low that it may be neglected
(d) both (b) and (c) (e) it moves easily.

110. Barometer is used to measure
(*a*) pressure in pipes, channels etc.
(*b*) atmospheric pressure
(*c*) very low pressure
(*d*) difference of pressure between two points
(*e*) rain level.

111. Which of the following instrument can be used for measuring speed of a submarine moving in deep sea ?
(*a*) Venturimeter (*b*) Orifice plate
(*c*) hot wire anemometer (*d*) rotameter
(*e*) pitot tube.

112. Which of the following instrument can be used for measuring speed of an aeroplane ?
(*a*) Venturimeter (*b*) Orifice plate
(*c*) hot wire anemometer (*d*) rotameter
(*e*) pitot tube.

113. Piezometer is used to measure
(*a*) pressure in pipe, channels etc.
(*b*) atmospheric pressure
(*c*) very low pressures
(*d*) difference of pressure between two points
(*e*) flow.

114. Which of the following instruments is used to measure flow on the application of Bernoulli's theorem ?
(*a*) Venturimeter (*b*) Orifice plate
(*c*) nozzle (*d*) pitot tube
(*e*) all of the above.

115. The speed of sound in a perfect gas is given by

(*a*) $\sqrt{\dfrac{k\text{ (ratio of specific heat capacities)}}{R\text{ (gas constant)} \times T\text{ (absolute temp)}}}$

(*b*) $\sqrt{kT/R}$ (*c*) $\sqrt{kR/T}$

(*d*) $\sqrt{kRT}$ (*e*) $(kRT)^2$.

116. The speed of sound in a ideal gas varies directly as its
(*a*) pressure (*b*) temperature
(*c*) density (*d*) modulus of elasticity
(*e*) absolute temperature.

117. Speed of sound in water is equal to

(*a*) $\sqrt{\dfrac{K\text{(bulb modulus)}}{\sigma\text{(density)}}}$ (*b*) $\sqrt{K\sigma}$

(*c*) $\sqrt{\sigma/K}$ (*d*) K/σ

(*e*) σ/K.

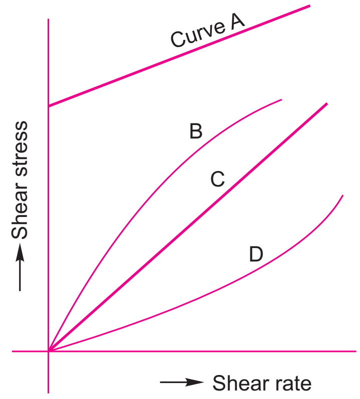
118. Flow maters based on obstruction principle like orifice plates can be used with Reynold's number upto approximately
(*a*) 500 (*b*) 1000
(*c*) 2000 (*d*) 4000
(*e*) 10000.

119. Dynamic viscosity of most of the liquids with rise in temperature
(*a*) increases (*b*) decreases
(*c*) remains unaffected (*d*) unpredictable
(*e*) none of the above.

120. Dynamic viscosity of most of the gases with rise in temperature
(*a*) increases (*b*) decreases
(*c*) remains unaffected (*d*) unpredictable
(*e*) none of the above.

121. A metal with specific gravity of σ floating in a fluid of same specific gravity σ will
(*a*) sink to bottom
(*b*) float over fluid
(*c*) partly immersed
(*d*) be fully immersed with top surface at fluid surface
(*e*) none of the above.

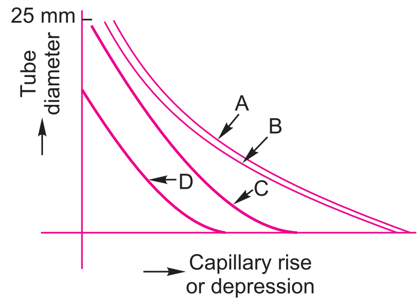
122. Which curve is applicable for the Newtonian fluid in Fig. below ?



(*a*) curve *A* (*b*) curve *B*
(*c*) curve *C* (*d*) curve *D*
(*e*) none of the above.

123. Euler's dimensionless number relates the following
(*a*) inertial force and gravity
(*b*) viscous force and inertial force
(*c*) viscous force and buoyancy force
(*d*) pressure force and inertial force
(*e*) pressure force and viscous force.

124. Fig. below shows the capillarity action in circular glass tubes for various liquids.



For mercury, following curve holds
(*a*) curve *A* (*b*) curve *B*
(*c*) curve *C* (*d*) curve *D*
(*e*) none of the above.

125. For tap water, following curve holds (Refer above Fig.)
(*a*) curve *A* (*b*) curve *B*

(*c*) curve *C* (*d*) curve *D*
(*e*) none of the above.

126. For distilled water at very low temperature following curve holds (Refer above Fig.)
(*a*) curve *A* (*b*) curve *B*
(*c*) curve *C* (*d*) curve *D*
(*e*) none of the above.

127. For distilled water at higher temperature, following curve holds (Refer above Fig.)
(*a*) curve *A* (*b*) curve *B*
(*c*) curve *C* (*d*) curve *D*
(*e*) none of the above.

128. Manometer is used to measure
(*a*) pressure in pipes, channels etc.
(*b*) atmospheric pressure
(*c*) very low pressure
(*d*) difference of pressure between two points
(*e*) velocity.

129. Which of the following manometer has highest sensitivity ?
(*a*) *U*-tube with water (*b*) inclined *U*-tube
(*c*) *U*-tube with mercury
(*d*) micro-manometer with water
(*e*) displacement type.

130. In order to increase sensitivity of *U*-tube manometer, one leg is usually inclined by angle θ. Sensitivity of inclined tube to sensitivity of *U*-tube is equal to
(*a*) $\sin\theta$ (*b*) $\frac{1}{\sin\theta}$
(*c*) $\cos\theta$ (*d*) $\frac{1}{\cos\theta}$
(*e*) $\tan\theta$.

131. Working principle of dead weight pressure gauge tester is based on
(*a*) Pascal's law
(*b*) Dalton's law of partial pressure
(*c*) Newton's law of viscosity
(*d*) Avogadro's hypothesis
(*e*) second law of thermodynamic.

132. The resultant of all normal pressures acts
(*a*) at c.g. of body (*b*) at centre of pressure
(*c*) vertically upwards (*d*) at metacentre
(*e*) vertically downwards.

133. Centre of pressure compared to c.g. is
(*a*) above it (*b*) below it
(*c*) at same point
(*d*) above or below depending on area of body
(*e*) none of the above.

134. Metacentric height is the distance between the metacentre and
(*a*) water surface (*b*) centre of pressure
(*c*) centre of gravity (*d*) centre of buoyancy
(*e*) none of the above.

135. The resultant upward pressure of the fluid on an immersed body due to its tendency to uplift the submerged body is called
(*a*) upthrust (*b*) reaction
(*c*) buoyancy (*d*) metacentre
(*e*) centre of pressure.

136. The centre of pressure of a surface subjected to fluid pressure is the point
(*a*) on the surface at which resultant pressure acts
(*b*) on the surface at which gravitational force acts
(*c*) at which all hydraulic forces meet
(*d*) similar to metacentre
(*e*) where pressure equivalent to hydraulic thrust will act.

137. Buoyant force is
(*a*) the resultant force acting on a floating body
(*b*) the resultant force on a body due to the fluid surrounding it
(*c*) equal to the volume of liquid displaced
(*d*) the force necessary to maintain equilibrium of a submerged body
(*e*) none of the above.

138. The horizontal component of buoyant force is
(*a*) negligible
(*b*) same as buoyant force
(*c*) zero
(*d*) "buoyant force" × tan θ
(*e*) none of the above.

139. The force of buoyancy is dependent on
(*a*) mass of liquid displaced
(*b*) viscosity of fluid
(*c*) surface tension of fluid
(*d*) depth of immersion
(*e*) centre of pressure.

140. The line of action of the buoyant force acts through the
(*a*) centroid of the volume of fluid vertically above the body
(*b*) centre of the volume of floating body
(*c*) centre of gravity of any submerged body
(*d*) centroid of the displaced volume of fluid
(*e*) none of the above.

141. Centre of buoyancy is the
(*a*) centroid of the displaced volume of fluid
(*b*) centre of pressure of displaced volume
(*c*) c.g. of floating body
(*d*) does not exist
(*e*) none of the above.

142. A body floats in stable equilibrium
(*a*) when its meatcentric height is zero
(*b*) when the metancentre is above c.g.
(*c*) when its c.g. is below it's centre of buoyancy
(*d*) metacentre has nothing to do with position of c.g. for determining stability
(*e*) none of the above.

143. A piece weighing 3 kg in air was found to weigh 2.5 kg when submerged in water. Its specific gravity is

(*a*) 1 (*b*) 5
(*c*) 7 (*d*) 6
(*e*) 12.

144. A vertical wall is subjected to liquid (of specific weight 'w') pressure on one side. If h be height of liquid surface, then total pressure on wall per unit length is

(*a*) wh (*b*) $\frac{wh}{2}$
(*c*) $\frac{wh^2}{2}$ (*d*) $\frac{2}{3}wh$
(*e*) $\frac{2}{3}wh^2$

145. The total pressure on the wall in above case acts at following distance from liquid surface

(*a*) $\frac{h}{2}$ (*b*) $\frac{h}{3}$
(*c*) $\frac{2}{3}h$ (*d*) $\frac{3}{4}h$
(*e*) $\frac{2}{5}h$.

146. The total pressure on a horizontally immersed surface (of surface area A) with its c.g. at a depth $\bar{x}$ from liquid surface in a liquid of specific weight w is

(*a*) $w \cdot A$ (*b*) $w \cdot \bar{x}$
(*c*) $\frac{wA}{\bar{x}}$ (*d*) $\frac{w\bar{x}}{A}$
(*e*) $wA\bar{x}$.

147. If the surface in above case is inclined at angle θ with the liquid surface, then total pressure on the immersed surface will be

(*a*) $wA\bar{x}$ (*b*) $wA\bar{x} \cos\theta$
(*c*) $wA\bar{x} \sin\theta$ (*d*) $wA\bar{x} \tan\theta$
(*e*) $wA\bar{x} \sec\theta$.

148. The location of resultant force acting on a body submerged in water (*i.e.,* depth of centre of pressure) will be

(*a*) $h_G + \frac{I_G}{h_G A}$ (*b*) $h_G + \frac{h_G A}{I_G}$
(*c*) $h_G - \frac{I_G}{h_G A}$ (*d*) $h_G + \frac{h_G}{I_G A}$
(*e*) $h_G + \frac{A}{h_G I_G}$

where, h_G = depth of the centroid of the surface,
A = area.
I_G = M.I. of the surface about an axis lying in the surface, passing through its centroid, and parallel to the free surface.

149. The centre of pressure for a vertically immersed surface lies at following distance from c.g.

(*a*) $\frac{I_G}{Ah_G}$ below (*b*) $\frac{I_G}{Ah_G}$ above
(*c*) 0 (*d*) $\frac{Ah_G}{I_G}$ below
(*e*) $\frac{Ah_G}{I_G}$ above.

150. The depth of centre of pressure for an immersed surface inclined at angle θ with the liquid surface lies at following distance from c.g.

(*a*) $\frac{I_G \sin^2\theta}{Ah_G}$ below (*b*) $\frac{I_G \sin^2\theta}{Ah_G}$ above
(*c*) $\frac{I_G \sin\theta}{Ah_G}$ below (*d*) $\frac{I_G \sin\theta}{A\bar{x}}$ above
(*e*) 0.

151. The total pressure force on a plane area is equal to the area multiplied by the intensity of pressure at the centroid, if

(*a*) the area is horizontal (*b*) the area is vertical
(*c*) the area is inclined (*d*) all of the above
(*e*) none of the above.

152. A square surface 3 m × 3 m lies in a vertical line in water with its upper edge at water surface. The hydrostatic force on square surface is

(*a*) 9,000 kg (*b*) 13,500 kg
(*c*) 18,000 kg (*d*) 27,000 kg
(*e*) 30,000 kg.

153. The depth of the centre of pressure on a vertical rectangular gate 8 m wide and 6 m high, when the water surface coincides with the top of the gate, is

(*a*) 2.4 m (*b*) 3.0 m
(*c*) 4.0 m (*d*) 2.5 m
(*e*) 5.0 m.

154. If the atmospheric pressure on the surface of an oil tank (sp. gr. 0.8) is 0.2 kg/cm^2, the pressure at a depth of 50 m below the oil surface will be

(*a*) 2 metres of water column
(*b*) 3 metres of water column
(*c*) 5 metres of water column
(*d*) 6 metres of water column
(*e*) 7 metres of water column.

155. Metacentre is the point of intersection of

(*a*) vertical upward force through c.g. of body and centre line of body
(*b*) buoyant force and the centre line of body
(*c*) mid point between c.g. and centre of buoyancy
(*d*) all of the above
(*e*) none of the above.

156. Choose the wrong statement

(*a*) The horizontal component of the hydro-static force on any surface is equal to the normal force on the vertical projection of the surface
(*b*) The horizontal component acts through the centre of pressure for the vertical projection
(*c*) The vertical component of the hydrostatic force on any surface is equal to the weight of the volume of the liquid above the area
(*d*) The vertical component passes through the centre of pressure of the volume

(*e*) Centre of pressure acts at a greater depth than centre of gravity.

157. For a body floating in a liquid the normal pressure exerted by the liquid acts at
(*a*) bottom surface of the body
(*b*) c.g. of the body (*c*) metacentre
(*d*) all points on the surface of the body
(*e*) all of the above.

158. Choose the wrong statement
(*a*) any weight, floating or immersed in a liquid, is acted upon by a buoyant force
(*b*) Buoyant force is equal to the weight of the liquid displaced
(*c*) The point through which buoyant force acts is called the centre of buoyancy
(*d*) Centre of buoyancy is located above the centre of gravity of the displaced liquid
(*e*) Relative density of liquids can be determined by means of the depth of flotation of hydrometer.

159. According to the principle of buoyancy a body totally or partially immersed in a fluid will be lifted up by a force equal to
(*a*) the weight of the body
(*b*) more than the weight of the body
(*c*) less than the weight of the body
(*d*) weight of the fluid displaced by the body
(*e*) weight of body plus the weight of the fluid displaced by the body.

160. When a body floating in a liquid, is displaced slightly, it oscillates about
(*a*) c.g. of body (*b*) centre of pressure
(*c*) centre of buoyancy (*d*) metacentre
(*e*) liquid surface.

161. Buoyant force is
(*a*) resultant force acting on a floating body
(*b*) equal to the volume of liquid displaced
(*c*) force necessary to keep a body in equilibrium
(*d*) the resultant force on a body due to the fluid surrounding it
(*e*) none of the above.

162. Ratio of inertia force to surface tension is known as
(*a*) Mach number (*b*) Froude number
(*c*) Reynold's number (*d*) Weber's number
(*e*) none of the above.

163. A ship whose hull length is 100 m is to travel at 10 m/sec. For dynamic similarity, at what velocity should a 1:25 model be towed through water ?
(*a*) 10 m/sec (*b*) 25 m/sec
(*c*) 2 m/sec (*d*) 50 m/sec
(*e*) 250 m/sec.

164. A model of a reservoir is drained in 4 mts by opening the sluice gate. The model scale is 1: 225. How long should it take to empty the prototype ?
(*a*) 900 minutes (*b*) 4 minutes
(*c*) $4 \times (225)^{3/2}$ minutes (*d*) $4\,(225)^{1/3}$ minutes
(*e*) $4 \times \sqrt{225}$ minutes.

165. A model of torpedo is tested in a towing tank at a velocity of 25 m/sec. The prototype is expected to attain a velocity of 5 m/sec. What model scale has been used ?
(*a*) 1 : 5 (*b*) 1 : 2.5
(*c*) 1 : 25 (*d*) $1 : \sqrt{5}$
(*e*) $1 : 5^{3/2}$.

166. Ratio of inertia force to elastic force is known as
(*a*) Mach number (*b*) Froude number
(*c*) Reynold's number (*d*) Weber's number
(*e*) none of the above.

167. For a floating body to be in stable equilibrium, its metacentre should be
(*a*) below the centre of gravity
(*b*) below the centre of buoyancy
(*c*) above the centre of buoyancy
(*d*) between c.g. and centre of pressure
(*e*) above the centre of gravity.

168. For a floating body to be in equilibrium
(*a*) meta centre should be above c.g.
(*b*) centre of buoyancy and c.g. must lie on same vertical plane
(*c*) a righting couple should be formed
(*d*) all of the above
(*e*) none of the above.

169. The two important forces for a floating body are
(*a*) buoyancy, gravity (*b*) buoyancy, pressure
(*c*) buoyancy, inertial (*d*) inertial, gravity
(*e*) gravity, pressure.

170. Choose the wrong statement
(*a*) The centre of buoyancy is located at the centre of gravity of the displaced liquid
(*b*) For stability of a submerged body, the centre of gravity of body must lie directly below the centre of buoyancy
(*c*) If c.g. and centre of buoyancy coincide, the submerged body must lie at neutral equilibrium for all positions
(*d*) For stability of floating cylinders or spheres, the c.g. of body must lie below the centre of buoyancy
(*e*) All floating bodies are stable.

171. Centre of pressure on an inclined plane is
(*a*) at the centroid (*b*) above the centroid
(*c*) below the centroid (*d*) at metacentre
(*e*) at centre of pressure.

172. An open vessel of water is accelerated up an inclined plane. The free water surface will
(*a*) be horizontal
(*b*) make an angle in direction of inclination of inclined plane
(*c*) make an angle in opposite direction to inclination of inclined plane
(*d*) any one of above is possible
(*e*) none of the above.

173. The line of action of the buoyant force acts through the centroid of the
(*a*) submerged body
(*b*) volume of the floating body
(*c*) volume of the fluid vertically above the body
(*d*) displaced volume of the fluid
(*e*) none of the above.

174. Resultant pressure of the liquid in the case of an immersed body acts through
(*a*) centre of gravity (*b*) centre of pressure
(*c*) metacentre (*d*) centre of buoyancy
(*e*) in between c.g. and centre of pressure.

175. The centre of gravity of the volume of the liquid displaced by an immersed body is called
(*a*) centre of gravity (*b*) centre of pressure
(*c*) metacentre (*d*) centre of buoyancy
(*e*) centroid.

176. Differential monometer is used to measure
(*a*) pressure in pipes, channels etc.
(*b*) atmospheric pressure
(*c*) very low pressure
(*d*) difference of pressure between two points
(*e*) velocity in pipes.

177. The pressure in the air space above an oil (sp. gr. 0.8) surface in a tank is 0.1 kg/cm^2. The pressure at 2.5 m below the oil surface will be
(*a*) 2 metres of water column
(*b*) 3 metres of water column
(*c*) 3.5 metres of water column
(*d*) 4 m of water column
(*e*) none of the above.

178. The time oscillation of a floating body with increase in metacentric height will be
(*a*) same (*b*) higher
(*c*) lower
(*d*) lower/higher depending on weight of body
(*e*) unpredictable.

179. In an immersed body, centre of pressure is
(*a*) at the centre of gravity
(*b*) above the centre of gravity
(*c*) below be centre of gravity
(*d*) could be above or below c.g., depending on density of body and liquid
(*e*) unpredictable.

180. The normal stress is same in all directions at a point in a fluid
(*a*) only when the fluid is frictionless
(*b*) only when the fluid is incompressible and has zero viscosity
(*c*) when there is no motion of one fluid layer relative to an adjacent layer
(*d*) irrespective of the motion of one fluid layer relative to an adjacent layer
(*e*) in case of an ideal fluid.

181. Select the correct statement
(*a*) Local atmospheric pressure depends upon elevation of locality only
(*b*) Standard atmospheric pressure is the mean local atmospheric pressure at sea level
(*c*) Local atmospheric pressure is always below standard atmospheric pressure
(*d*) A barometer reads the difference between local and standard atmospheric pressure
(*e*) Gauge pressure is equal to atmospheric pressure plus instrument reading.

182. Gauge pressure is equal to
(*a*) absolute pressure + atmospheric pressure
(*b*) absolute pressure – atmospheric pressure
(*c*) atmospheric pressure – absolute pressure
(*d*) atmospheric pressure – vacuum
(*e*) atmospheric pressure + vacuum.

183. The equation of continuity of flow is based on the principle of conservation of
(*a*) flow (*b*) mass
(*c*) momentum (*d*) energy
(*e*) mass, momentum and energy.

184. For measuring flow by a venturimeter, it should be installed in
(*a*) vertical line (*b*) horizontal line
(*c*) inclined line with flow downward
(*d*) inclined line with upward flow
(*e*) in any direction and in any location.

185. Total pressure on a 1 m × 1 m gate immersed vertically at a depth of 2 m below the free water surface will be
(*a*) 1000 kg (*b*) 4000 kg
(*c*) 2000 kg (*d*) 8000 kg
(*e*) 16000 kg.

186. Hot wire anemometer is used to measure
(*a*) pressure in gases (*b*) liquid discharge
(*c*) pressure in liquids (*d*) gas velocities
(*e*) temperature.

187. Rotameter is a device used to measure
(*a*) absolute pressure (*b*) velocity of fluid
(*c*) flow (*d*) rotation
(*e*) velocity of air.

188. Flow of water in a pipe about 3 metres in diameter can be measured by
(*a*) orifice plate (*b*) venturi
(*c*) rotameter (*d*) pitot tube
(*e*) nozzle.

189. True one-dimensional flow occurs when
(*a*) the direction and magnitude of the velocity at all points are identical
(*b*) the velocity of successive fluid particles, at any point, is the same at successive periods of time
(*c*) the magnitude and direction of the velocity do not change from point to point in the fluid
(*d*) the fluid particles move in plane or parallel planes and the streamline patterns are identical in each plane
(*e*) velocity, depth, pressure etc. change from point to point in the fluid flow.

190. An ideal flow of any fluid must satisfy
(*a*) Pascal law
(*b*) Newton's law of viscosity
(*c*) boundary layer theory
(*d*) continuity equation
(*e*) Bernoulli's theorem.

191. In the case of steady flow of a fluid, the acceleration of any fluid particle is
(*a*) constant (*b*) variable
(*c*) zero
(*d*) zero under limiting conditions
(*e*) never zero.

192. The depth of centre of pressure in a rectangular lamina of height h with one side in the liquid surface is at
(*a*) h (*b*) $\frac{h}{3}$
(*c*) $\frac{2h}{3}$ (*d*) $\frac{h}{2}$
(*e*) $\frac{3}{4}h$.

193. Non uniform flow occurs when
(*a*) the direction and magnitude of the velocity at all points are identical
(*b*) the velocity of successive fluid particles, at any point, is the same at successive periods of time
(*c*) the magnitude and direction of the velocity do not change from point to point in the fluid
(*d*) the fluid particles move in plane or parallel planes and the streamline patterns are identical in each plane
(*e*) velocity, depth, pressure, etc. change from point to point in the fluid flow.

194. During the opening of a valve in a pipe line, the flow is
(*a*) steady (*b*) unsteady
(*c*) uniform (*d*) laminar
(*e*) free vortex type.

195. Uniform flow occurs when
(*a*) the flow is steady
(*b*) the flow is streamline
(*c*) size and shape of the cross section in a particular length remain constant
(*d*) size and cross section change uniformly along length
(*e*) flow occurs at constant rate.

196. Gradually varied flow is
(*a*) steady uniform
(*b*) non-steady non-uniform
(*c*) non-steady uniform
(*d*) steady non-uniform
(*e*) true one-dimensional.

197. Steady flow occurs when
(*a*) the direction and magnitude of the velocity at all points are identical
(*b*) the velocity of successive fluid particles, at any point, is the same at successive periods of time
(*c*) the magnitude and direction of the velocity do not change from point to point in the fluid
(*d*) the fluid particles move in plane or parallel planes and the streamline patterns are identical in each plane
(*e*) velocity, depth, pressure, etc. change from point to point in the fluid flow.

198. The flow which neglects changes in a transverse direction is known as
(*a*) one dimensional flow (*b*) uniform flow
(*c*) steady flow (*d*) turbulent flow
(*e*) streamline flow.

199. The flow in which each liquid particle has a definite path and their paths do not cross each other is called
(*a*) one dimensional flow (*b*) uniform flow
(*c*) steady flow (*d*) turbulent flow
(*e*) streamline flow.

200. The flow in which conditions do not change with time at any point, is known as
(*a*) one dimensional flow
(*b*) uniform flow (*c*) steady flow
(*d*) turbulent flow (*e*) streamline flow.

201. The flow in which the velocity vector is identical in magnitude and direction at every point, for any given instant, is known as
(*a*) one dimensional flow (*b*) uniform flow
(*c*) steady flow (*d*) turbulent flow
(*e*) streamline flow.

202. The flow in which the particles of a fluid attain such velocities that vary from point to point in magnitude and direction as well as from instant to instant, is known as
(*a*) one dimensional flow (*b*) uniform flow
(*c*) steady flow (*d*) turbulent flow
(*e*) streamline flow.

203. Which of the following is Chezy's formula for determining flow in open channel ?
(*a*) $v = \frac{1}{n} m^{2/3} i^{1/2}$ (*b*) $v = C\sqrt{mi}$
(*c*) $v = \dfrac{157.6}{1.81 + \dfrac{K}{\sqrt{m}}} \sqrt{mi}$
(*d*) $v = \dfrac{23 + \dfrac{0.00155}{i} + \dfrac{1}{n}}{1 + \left(23 + \dfrac{0.00155}{i}\right)\dfrac{n}{\sqrt{m}}} \sqrt{mi}$
(*e*) none of the above.
where, v = mean velocity of flow,
i = slope of channel,
m = hydraulic mean depth,
C, n, and K are constants.

204. Venturimeter is used to measure flow of fluids in pipes when pipe is
(*a*) horizontal
(*b*) vertical, flow downwards
(*c*) vertical, flow upwards

(*d*) inclined position
(*e*) in any position.

205. Which of the following is the Manning's formula for determining flow in open channel?

(*a*) $v = \frac{1}{n} m^{2/3} i^{1/2}$ (*b*) $v = C\sqrt{mi}$

(*c*) $v = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}\sqrt{mi}$

(*d*) $v = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{m}}}\sqrt{mi}$

(*e*) none of the above.

where, v = mean velocity of flow,
i = slope of channel,
m = hydraulic mean depth,
C, n, and K are constants.

206. The length of divergent portion of venturimeter in comparision to convergent portion is
(*a*) same (*b*) more
(*c*) less
(*d*) more or less depending on capacity
(*e*) no correlation.

207. Which of the following is the Darcy or Weisbach equation ?

(*a*) $v = \frac{1}{n} m^{2/3} i^{1/2}$ (*b*) $v = C\sqrt{mi}$

(*c*) $v = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}\sqrt{mi}$

(*d*) $v = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{m}}}\sqrt{mi}$

(*e*) none of the above.

where, v = mean velocity of flow,
i = slope of channel,
m = hydraulic mean depth,
C, n, and K are constants.

208. Which of the following is Bazin's formula ?

(*a*) $v = \frac{1}{n} m^{2/3} i^{1/2}$

(*b*) $v = C\sqrt{mi}$

(*c*) $v = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}\sqrt{mi}$

(*d*) $v = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{m}}}\sqrt{mi}$

(*e*) none of the above.

where, v = mean velocity of flow,
i = slope of channel,
m = hydraulic mean depth,
C, n, and K are constants.

209. Which of the following is Kutter's formula?

(*a*) $v = \frac{1}{n} m^{2/3} i^{1/2}$ (*b*) $v = C\sqrt{mi}$

(*c*) $v = \frac{157.6}{1.81 + \frac{K}{\sqrt{m}}}\sqrt{mi}$

(*d*) $v = \frac{23 + \frac{0.00155}{i} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{i}\right)\frac{n}{\sqrt{m}}}\sqrt{mi}$

(*e*) none of the above.

where, v = mean velocity of flow,
i = slope of channel,
m = hydraulic mean depth,
C, n, and K are constants.

210. Flow occurring in a pipeline when a valve is being opened is
(*a*) steady (*b*) unsteady
(*c*) laminar (*d*) vortex
(*e*) rotational.

211. General energy equation holds for
(*a*) steady flow (*b*) turbulent flow
(*c*) laminar flow (*d*) non-uniform flow
(*e*) all of the above.

212. A streamline is defined as the line
(*a*) parallel to central axis flow
(*b*) parallel to outer surface of pipe
(*c*) of equal velocity in a flow
(*d*) along which the pressure drop is uniform
(*e*) which occurs in all flows.

213. Two dimensional flow occurs when
(*a*) the direction and magnitude of the velocity at all points are identical
(*b*) the velocity of successive fluid particles, at any point, is the same at successive periods of time
(*c*) the magnitude and direction of the velocity do not change from point to point in the fluid
(*d*) the fluid particles move in plane or parallel planes and the streamline patterns are identical in each plane
(*e*) velocity, depth, pressure, etc. change from point to point in the fluid flow.

214. In case of rectangular lamina with side in liquid surface having depth h, the depth of centre of pressure will be

(*a*) $\frac{2h}{3}$ (*b*) $\frac{h}{2}$

(*c*) $\frac{3h}{4}$ (*d*) $\frac{h}{3}$

(*e*) $\frac{3h}{8}$.

215. A piece of metal of specific gravity 7 floats in mercury of specific gravity 13.6. What fraction of its volume is under mercury ?
(*a*) 0.5 (*b*) 0.4
(*c*) 0.515 (*d*) 0.5
(*e*) none of the above.

216. A piece of wood having weight 5 kg floats in water with 60% of its volume under the liquid. The specific gravity of wood is
(*a*) 0.83 (*b*) 0.6
(*c*) 0.4 (*d*) 0.3
(*e*) none of the above.

217. Three vessels of inverted pyramid, semi-spherical, *V*-trough shapes having same volume and same height are to be emptied by an equal area opening. Times for emptying in order will be
(*a*) semi-sphere, inverted pyramid, *V*-trough
(*b*) inverted pyramid, semi-sphere, *V*-trough
(*c*) inverted pyramid, *V*-trough, semi-sphere
(*d*) semi-sphere, *V*-trough, inverted pyramid
(*e*) *V*-trough, semi-sphere, inverted pyramid.

218. The velocity of jet of water travelling out of opening in a tank filled with water is proportional to
(*a*) head of water (h) (*b*) h^2
(*c*) $\sqrt{h}$ (*d*) h^3
(*e*) $h^{3/2}$.

219. In a free vortex motion, the radial component of velocity everywhere is
(*a*) maximum (*b*) minimum
(*c*) zero (*d*) non-zero and finite
(*e*) unpredictable.

220. In a forced vortex, the velocity of flow everywhere within the fluid is
(*a*) maximum (*b*) minimum
(*c*) zero (*d*) non-zero finite
(*e*) unpredictable.

221. The region between the separation streamline and the boundary surface of the solid body is known as
(*a*) wake (*b*) drag
(*c*) lift (*d*) boundary layer
(*e*) aerofoil section.

222. For hypersonic flow, the Mach number is
(*a*) unity (*b*) greater than unity
(*c*) greater than 2 (*d*) greater than 4
(*e*) greater than 10.

223. The upper surface of a weir over which water flows is known is
(*a*) crest (*b*) nappe
(*c*) sill (*d*) weir top
(*e*) contracta.

224. Normal depth in open channel flow is the depth of flow corresponding to
(*a*) steady flow (*b*) unsteady flow
(*c*) laminar flow (*d*) uniform flow
(*e*) critical flow.

225. Velocity distribution in the turbulent boundary layer following law
(*a*) linear (*b*) square
(*c*) parabola (*d*) logarithmic
(*e*) cubic.

226. Uniform flow occurs when
(*a*) the direction and magnitude of the velocity at all points are identical
(*b*) the velocity of successive fluid particles, at any point, is the same at successive periods of time
(*c*) the magnitude and direction of the velocity do not change from point to point in the fluid
(*d*) the fluid particles move in plane or parallel planes and the streamline patterns are identical in each plane
(*e*) velocity, depth, pressure, etc. change from point to point in the fluid flow.

227. Pitot tube is used for measurement of
(*a*) pressure (*b*) flow
(*c*) velocity (*d*) discharge
(*e*) viscosity.

228. Hydrometer is used to determine
(*a*) specific gravity of liquids
(*b*) specific gravity of solids
(*c*) specific gravity of gases
(*d*) relative humidity
(*e*) density.

229. The total energy of each particle at various places in the case of perfect incompressible fluid flowing in continuous sream
(*a*) keeps on increasing (*b*) keeps on decreasing
(*c*) remains constant (*d*) may increase/decrease
(*e*) unpredictable.

230. According to Bernoulli's equation for steady ideal fluid flow
(*a*) principle of conservation of mass holds
(*b*) velocity and pressure are inversely proportional
(*c*) total energy is constant throughout
(*d*) the energy is constant along a streamline but may vary across streamlines
(*e*) none of the above.

231. The equation of continuity holds good when the flow
(*a*) is steady (*b*) is one dimensional
(*c*) velocity is uniform at all the cross-sections
(*d*) all of the above (*e*) none of the above.

232. Mach number is significant in
(*a*) supersonics, as with projectiles and jet propulsion
(*b*) full immersion or completely enclosed flow, as with pipes, aircraft wings, nozzles etc.
(*c*) simultaneous motion through two fluids where there is a surface of discontinuity, gravity force, and wave making effects, as with ship's hulls
(*d*) all of the above
(*e*) none of the above.

233. Froude number is significant in
(*a*) supersonics, as with projectile and jet propulsion
(*b*) full immersion or completely enclosed flow, as with pipes, aircraft wings, nozzles etc.
(*c*) simultaneous motion through two fluids where there is a surface of discontinuity, gravity forces, and wave making effect, as with ship's hulls
(*d*) all of the above
(*e*) none of the above

234. All the terms of energy in Bernoulli's equation have dimension of
(*a*) energy (*b*) work
(*c*) mass (*d*) length
(*e*) time.

235. Reynolds number is significant in
(*a*) supersonics, as with projectile and jet propulsion
(*b*) full immersion or completely enclosed flow, as with pipes, aircraft wings, nozzles etc.
(*c*) simultaneous motion through two fluids where there is a surface of discontinuity, gravity forces, and wave making effect, as with ship's hulls
(*d*) all of the above (*e*) none of the above.

236. The fluid forces considered in the Navier Stokes equation are
(*a*) gravity, pressure and viscous
(*b*) gravity, pressure and turbulent
(*c*) pressure, viscous and turbulent
(*d*) gravity, viscous and turbulent
(*e*) none of the above.

237. A large Reynold number is indication of
(*a*) smooth and streamline flow
(*b*) laminar flow (*c*) steady flow
(*d*) turbulent flow (*e*) highly turbulent flow.

238. The friction head lost due to the flow of a viscous fluid through a circular pipe of length L and diameter d with a velocity v, and pipe friction factor 'f' is
(*a*) $\frac{4fL}{d} \cdot \frac{v^2}{2g}$ (*b*) $\frac{4fL}{\pi d^2} \cdot \frac{v^2}{2g}$
(*c*) $\frac{\frac{4fL}{v^2}}{2g}$ (*d*) $\frac{4fL}{\pi d} \cdot \frac{v^2}{2g}$
(*e*) none of the above.

239. For pipes, laminar flow occurs when Reynolds number is
(*a*) less than 2000
(*b*) between 2000 and 4000
(*c*) more than 4000
(*d*) less than 4000
(*e*) none of the above.

240. In order that flow takes place between two points in a pipeline, the differential pressure between these points must be more than
(*a*) frictional force (*b*) viscosity
(*c*) surface friction (*d*) all of the above
(*e*) none of the above.

241. At the centre line of a pipe flowing under pressure where the velocity gradient is zero, the shear stress will be
(*a*) minimum (*b*) maximum
(*c*) zero (*d*) negative value
(*e*) could be any value.

242. The pressure in Pascals at a depth of 1 m below the free surface of a body of water will be equal to
(*a*) 1 Pa (*b*) 98.1Pa
(*c*) 981 Pa (*d*) 9810 Pa
(*e*) 98,100 Pa.

243. The expression for relation between the gauge pressure p inside a liquid droplet (*i.e.*, difference of pressure between the inside and outside of a liquid drop) of diameter d and the surface tension σ is
(*a*) $\sigma = pd$ (*b*) $\sigma = \pi pd$
(*c*) $\sigma = \frac{pd}{\pi}$ (*d*) $\sigma = 4pd$
(*e*) $\sigma = \frac{pd}{4}$.

244. Two pipe systems can be said to be equivalent, when the following quantites are same
(*a*) friction loss and flow
(*b*) length and diameter
(*c*) flow and length
(*d*) friction factor and diameter
(*e*) velocity and diameter.

245. For pipes, turbulent flow occurs when Reynolds number is
(*a*) less than 2000
(*b*) between 2000 and 4000
(*c*) more than 4000 (*d*) less than 4000
(*e*) none of the above.

246. Bernoulli equation deals with the law of conservation of
(*a*) mass (*b*) momentum
(*c*) energy (*d*) work
(*e*) force.

247. A hydraulic press has a ram of 15 cm diameter and plunger of 1.5 cm. It is required to lift a weight of 1 tonne. The force required on plunger is equal to
(*a*) 10 kg (*b*) 100 kg
(*c*) 1000 kg (*d*) 1 kg
(*e*) 10,000 kg.

248. Cavitation is caused by
(*a*) high velocity (*b*) high pressure
(*c*) weak material (*d*) low pressure
(*e*) low viscosity.

249. Cavitation will begin when
(*a*) the pressure at any location reaches an absolute pressure equal to the saturated vapour pressure of the liquid
(*b*) pressure becomes more than critical pressure
(*c*) flow is increased
(*d*) pressure is increased
(*e*) none of the above.

250. Principle of similitude forms the basis of
(*a*) comparing two identical equipments
(*b*) designing models so that the result can be converted to prototypes
(*c*) comparing similarity between design and actual equipment
(*d*) hydraulic designs
(*e*) performing acceptance tests.

251. For similarity, in addition to models being geometrically similar to prototype, the following in both cases should also be equal
(*a*) ratio of inertial force to force due to viscosity
(*b*) ratio of inertial force to force due to gravitation
(*c*) ratio of inertial force to force due to surface tension
(*d*) all the four ratios of inertial force to force due to viscosity, gravitation, surface tension, and elasticity
(*e*) none of the above.

252. If V is the mean velocity of flow, then according to Darcy-Weisbach equation for pipe flow, energy loss over a length of pipe line is proportional to
(*a*) V (*b*) $\frac{1}{V}$
(*c*) V^2 (*d*) $\frac{1}{V^2}$
(*e*) $\sqrt{V}$.

253. Froude number is the ratio of inertial force to
(*a*) gravitation force (*b*) surface tension
(*c*) elasticity (*d*) viscosity
(*e*) none of the above.

254. The non-dimensional factor governing viscous or frictional resistance is
(*a*) Reynolds number (*b*) Weber number
(*c*) Froude number (*d*) Mach number
(*e*) none of the above.

255. Euler's dimensionless number relates
(*a*) pressure force and inertia force
(*b*) pressure force and viscous force
(*c*) inertia force and gravity force
(*d*) buoyancy force and viscous force
(*e*) inertia force and viscous force.

256. The rate of change of linear momentum equals
(*a*) active force (*b*) reactive force
(*c*) torque (*d*) work done
(*e*) power.

257. Mach number is the ratio of inertial force to
(*a*) gravitation force (*b*) surface tension
(*c*) elasticity (*d*) viscosity
(*e*) none of the above.

258. Mach number greater than unity implies that the flow is
(*a*) sonic (*b*) subsonic
(*c*) supersonic (*d*) hypersonic
(*e*) associated with shocks.

259. The component of the force of the fluid on the body (which is generally inclined to the direction of motion of the body) parallel to the direction of motion is called
(*a*) drag (*b*) lift
(*c*) wake (*d*) propelling force
(*e*) thrust.

260. The rate of change of moment of momentum represents the
(*a*) force exerted by fluid
(*b*) torque applied by the fluid
(*c*) work done by the fluid
(*d*) power developed by the fluid
(*e*) none of the above.

261. Reynolds number is the ratio of intertial force to
(*a*) gravitational force (*b*) surface tension
(*c*) elasticity (*d*) viscosity
(*e*) none of the above.

262. The energy loss in flow through nozzle as compared to venturimeter is
(*a*) same (*b*) more
(*c*) less
(*d*) more/less depending on flow
(*e*) unpredictable.

263. Weber number is the ratio of intertial force to
(*a*) gravitational force (*b*) surface tension
(*c*) elasticity (*d*) viscosity
(*e*) none of the above.

264. Pressure coefficient is the ratio of pressure force to
(*a*) inertia force (*b*) gravity force
(*c*) viscous force (*d*) surface tension
(*e*) elasticity.

265. The pressure coefficient may take the form
(*a*) $\Delta P/\sigma\mu\nu$ (*b*) $\Delta P/(\sigma\nu^2/2)$
(*c*) $\Delta P/\frac{\mu^2 l^4}{\sigma}$ (*d*) $\frac{\sigma\mu^2}{2\Delta P}$
(*e*) none of the above.

266. Separation of flow occurs when pressure gradient
(*a*) tends to approach zero
(*b*) becomes negative
(*c*) changes abruptly
(*d*) reduces to a value when vapour formation starts
(*e*) does not follow continuity equation.

267. In laminar flow friction resistance is dependent on
(*a*) area of surface in contact
(*b*) (area of surface in contact)^2
(*c*) $\sqrt{\text{area of surface in contact}}$
(*d*) (area of surface in contact)$^{3/2}$
(*e*) none of the above.

268. Darcy-Weisabach equation for loss of head in pipe is
(*a*) $f\frac{L}{4m}\cdot\frac{V^2}{2g}$ (*b*) $f\frac{L}{m}\frac{V^2}{2g}$
(*c*) $f\frac{4L}{m}\frac{V^2}{2g}$ (*d*) $f\frac{4m}{L}\frac{V^2}{2g}$

(*e*) $f \frac{m}{4L} \frac{V^2}{2g}$.

where, f = friction factor, L = length, V = velocity

$m = \frac{A}{P}$ = area/wetted perimeter

m = hydraulic radius.

269. Which of the following is not a dimensionless parameter ?
(*a*) Reynolds number (*b*) friction factor
(*c*) pressure coefficient (*d*) kinematic viscosity
(*e*) all of the above.

270. When a boundary layer leaves a surface and curves up into a vortex or whirloop, it is known as
(*a*) drag (*b*) wake
(*c*) cavitation (*d*) separation
(*e*) boundary layer separation.

271. A dimensionless combination of ΔP, ρ, l, Q is
(*a*) $\sqrt{\frac{\Delta P}{\rho}} \frac{Q}{l^2}$ (*b*) $\sqrt{\frac{\rho}{\Delta P}} \frac{Q}{l^2}$
(*c*) $\frac{\Delta P l Q}{\rho}$ (*d*) $\frac{\rho Q}{\Delta P l^2}$
(*e*) none of the above.

272. Orifice is an opening
(*a*) with closed perimeter and of regular form through which water flows
(*b*) with prolonged sides having length of 2 to 3 diameters of opening in thick wall
(*c*) with partially full flow
(*d*) in hydraulic structure with regulation provision
(*e*) none of the above.

273. The average value of coefficient of velocity is of the order of
(*a*) 0.56 (*b*) 0.68
(*c*) 0.78 (*d*) 0.89
(*e*) 0.97.

274. The coefficients of discharge, velocity and contraction C_d, C_v, and C_c are related as
(*a*) $C_d = C_v + C_c$ (*b*) $C_d = C_v - C_c$
(*c*) $C_d = C_c - C_v$ (*d*) $C_d = C_c/C_v$
(*e*) $C_d = C_c \times C_v$.

275. The actual velocity at vena contracta for flow through an orifice from a reservior of height H =
(*a*) $\sqrt{2gH}$ (*b*) $C_v\sqrt{2gH}$
(*c*) $\sqrt{2gH}/C_v$ (*d*) $C_d\sqrt{2gH}$
(*e*) $C_d/\sqrt{2gH}$.

276. The ratio of actual discharge to theoretical discharge through an orifice is
(*a*) C_c/D_d (*b*) C_d/C_v
(*c*) C_d/C_v (*d*) $C_c\, C_v$
(*e*) $C_v C_d$.

277. The value of coefficient of discharge in comparison to coefficient of velocity is
(*a*) more (*b*) less
(*c*) same
(*d*) more/less depending on flow
(*e*) unpredictable.

278. For frictionless fluid, the contraction coefficient for Borda's mouthpiece is
(*a*) 1 (*b*) 0.5
(*c*) 0 (*d*) 0.97
(*e*) 0.8.

279. A mouthpiece can't be used under very large head because of
(*a*) creation of vortex at vena contracta
(*b*) cavitation problem at vena contracta
(*c*) large variation of discharge
(*d*) erratic flow
(*e*) contraction becomes too high.

280. A fluid jet discharging from a 100 mm diameter orifice has a diameter 80 mm at its vena contracta. The coefficient of contraction is
(*a*) 0.8 (*b*) 1.25
(*c*) 0.2 (*d*) 0.64
(*e*) 0.36.

281. In order that no shock wave develops when flow is taking place through a converging diverging tube, Mach number at exit should be
(*a*) = 1 (*b*) < 1
(*c*) > 1 (*d*) not critical
(*e*) there is no such criterion.

282. Weir in an opening
(*a*) with closed perimeter and of regular form through which water flows
(*b*) with prolonged sides having length of 2 to 3 diameters of opening in thick wall
(*c*) with partially full flow
(*d*) in hydraulic structure with regulation provision
(*e*) none of the above.

283. The region downstream from the streamline where separation takes place from the boundary is known as
(*a*) wake (*b*) lift
(*c*) drag (*d*) cavitation
(*e*) boundary layer separation.

284. Choose the wrong statement about flow nets
(*a*) flow nets are drawn to indicate flow patterns in case of one dimensional flow
(*b*) flow net consists of a system of streamlines so spaced that the rate of flow is the same between each successive pair of lines
(*c*) flow net consists of another system of lines normal to the streamlines and so spaced that the distance between the normal lines equals the distance between adjacent streamlines
(*d*) an infinite number of streamlines are required to describe completely the flow under given boundary condition
(*e*) It is usual practice to use a small number of such streamlines, as long as acceptable accuracy is obtained.

285. Continuity equation for a compressible fluid is
(*a*) $A_1V_1 = A_2V_2$
(*b*) $\rho_1A_1V_1 = \rho_2A_2V_2$ (A = area)
(*c*) $\frac{A_1V_1}{\rho_1} = \frac{A_2V_2}{\rho_2}$ (V = velocity)
(*d*) $\frac{\rho_1A_1}{V_1} = \frac{\rho_2A_2}{V_2}$ (ρ = density)
(*e*) $\frac{\rho_1V_1}{A_1} = \frac{\rho_1V_2}{A_2}$.

286. The continuity equation
(*a*) is based on Bernoulli's theorem
(*b*) expresses relation between work and energy
(*c*) expresses relation between hydraulic parameters of flow
(*d*) relates the mass rate of flow along a streamline
(*e*) is used to determine flow by pitot tube.

287. Equation of continuity of flow is based on the principle of conservation of
(*a*) mass (*b*) force
(*c*) momentum (*d*) energy
(*e*) hydraulic pressure.

288. Bernoulli's theorem deals with the conservation of
(*a*) mass (*b*) force
(*c*) momentum (*d*) energy
(*e*) hydraulic pressure.

289. The drag coefficient for laminar flow varies as proportional to
(*a*) Re (*b*) Re^{-1}
(*c*) $\text{Re}^{1/2}$ (*d*) $\text{Re}^{-1/2}$
(*e*) $\text{Re}^{3/2}$
(where, Re = Reynolds number).

290. Continuity equation for an incompressible fluid is
(*a*) $A_1V_1 = A_2V_2$
(*b*) $\rho_1A_1V_1 = \rho_2A_2V_2$ (A = area)
(*c*) $\frac{A_1V_1}{\rho_1} = \frac{A_2V_2}{\rho_2}$ (V = velocity, ρ = density)
(*d*) $\frac{\rho_1A_1}{V_1} = \frac{\rho_2A_2}{V_2}$ (*e*) $\frac{\rho_1V_1}{A_1} = \frac{\rho_1V_2}{A_2}$.

291. For maximum discharge through a circular open channel, the ratio of depth of flow to diameter of channel should be
(*a*) 0.9 (*b*) 0.5
(*c*) 0.65 (*d*) 0.85
(*e*) 0.95.

292. An air vessel is usually provided at the summit of a syphon in order to
(*a*) regulate the flow
(*b*) increase discharge
(*c*) avoid interruption in flow
(*d*) increase velocity
(*e*) increase height of syphon.

293. The flow at critical depth in an open channel is
(*a*) maximum (*b*) minimum
(*c*) zero (*d*) half of normal flow
(*e*) critical.

294. Tube is an opening
(*a*) with closed perimeter and of regular form through which water flows
(*b*) with prolonged sides having length of 2–3 diameters of opening in thick wall
(*c*) with partially full flow
(*d*) in hydraulic structure with regulation provision
(*e*) none of the above.

295. Highest efficiency is obtained with following channel section
(*a*) circular (*b*) triangular
(*c*) rectangular (*d*) quadrant
(*e*) trapezoidal.

296. For best hydraulic rectangular cross-section of an open channel, its depth should be equal to
(*a*) width (*b*) 2 width
(*c*) $\frac{\text{width}}{2}$ (*d*) $\sqrt{\text{width}}$
(*e*) $\frac{3}{8}$ width.

297. A triangular section in open channel flow will be most economical when the vertex angle at the triangle base point is
(*a*) 30° (*b*) 45°
(*c*) 60° (*d*) 90°
(*e*) 120°.

298. The discharge over a *V*-notch weir is proportional to
(*a*) $h^{3/2}$ (*b*) $h^{5/2}$
(*c*) $h^{1/2}$ (*d*) $h^{-3/2}$
(*e*) $h^{-5/2}$.

299. The motion of a fluid is vortex if each particle of the fluid moves in a circular path with the speed which
(*a*) is constant
(*b*) is directly proportional to distance from centre
(*c*) varies as square of distance from centre
(*d*) varies inversely as the distance from centre
(*e*) varies inversely as square of distance from centre.

300. Time required to empty uniform rectangular tank is proportional to its
(*a*) height H (*b*) $\sqrt{H}$
(*c*) H^2 (*d*) $H^{3/2}$
(*e*) $\frac{1}{\sqrt{H}}$.

301. The laminar sub-layer acts as
(*a*) an insulating medium
(*b*) good conductor of heat
(*c*) refractory substance (*d*) heat absorber
(*e*) heat generator.

302. A mouth-piece can't be used for emptying tanks with large heads because
(*a*) cavitation occurs at vena contracta
(*b*) vortex is created at vena contracta
(*c*) variation in discharge is high
(*d*) flow-through mouth piece is erratic
(*e*) flow becomes turbulent.

303. Gate is an opening
(*a*) with closed perimeter and of regular form through which water flows
(*b*) with prolonged sides having length of 2–3 diameters of opening in thick wall
(*c*) with partially full flow
(*d*) in hydraulic structure with regulation provision
(*e*) none of the above.

304. The value of coefficient of velocity for a sharp edged orifice is of the order of
(*a*) 0.45 (*b*) 0.5
(*c*) 0.62 (*d*) 0.78
(*e*) 0.98.

305. The value of coefficient of velocity depends upon
(*a*) slope of orifice (*b*) size of orifice
(*c*) head of liquid above orifice
(*d*) type of orifice
(*e*) friction at the orifice surface.

306. The contraction of area for flow through orifice in tank depends on
(*a*) shape of orifice (*b*) size of orifice
(*c*) head in tank (*d*) all of the above
(*e*) none of the above.

307. In an external mouthpiece, value of coefficient of discharge, if pipe is flowing full, will be
(*a*) 0.602 (*b*) 0.75
(*c*) 0.86 (*d*) 0.98
(*e*) 1.0.

308. The horizontal component of force on a curved surface is equal to the
(*a*) product of pressure at its centroid and area
(*b*) weight of liquid retained by the curved area
(*c*) force on a vertical projection of the curved surface
(*d*) weight of liquid vertically above the curved surface
(*e*) none of the above.

309. The vertical component of pressure force on a submerged curved surface is equal to
(*a*) weight of liquid vertically above the curved surface and extending upon the free surface
(*b*) the force on a vertical projection of the curved surface
(*c*) the product of pressure at centroid and surface area
(*d*) horizontal component (*e*) none of the above.

310. A block of ice floating over water in a vessel slowly melts in it. The water level in the vessel will
(*a*) start rising (*b*) start falling
(*c*) will remain constant
(*d*) will depend on temperature in water
(*e*) be unpredictable.

311. Manning formula is used to determine
(*a*) head loss due to friction in pipes flowing full under pressure
(*b*) head loss due to friction in open channels
(*c*) flow in open channels
(*d*) flow in pipes
(*e*) pressure in open channels.

312. The hydraulic radius in the case of an open channel with great width is equal to
(*a*) depth of channel
(*b*) 1/2 × depth of channel
(*c*) 1/3 × depth of channel
(*d*) 1/4 × depth of channel
(*e*) 3/8 × depth of channel.

313. In open channel corresponding to critical depth, the discharge is
(*a*) maximum (*b*) minimum
(*c*) zero flow (*d*) turbulent flow
(*e*) most economical.

314. If a water tank partially filled with water is being carried on a truck moving with a constant-horizontal acceleration, the level of the liquid will
(*a*) rise on the front side of the tank
(*b*) fall on the back side of the tank
(*c*) remain the same at both the sides of the tank
(*d*) rise on the back side and fall on the front side
(*e*) unpredictable.

315. The discharge over a sharp-edged rectangular notch of width w and depth h is equal to
(*a*) $\frac{2}{3}C_d w\sqrt{2g}\,h^{5/2}$ (*b*) $\frac{2}{3}C_d w\sqrt{2g}\,h$
(*c*) $\frac{2}{3}C_d w\sqrt{2g}\,h^{3/2}$ (*d*) $\frac{8}{15}C_d w\sqrt{2g}\,h^{3/2}$
(*e*) $\frac{8}{15}C_d w\sqrt{2g}\,h^{5/2}$.

316. The discharge through an orifice fitted in a tank can be increased by
(*a*) fitting a short length of pipe to the outside
(*b*) sharpening the edges of orifice
(*c*) fitting a long length of pipe to the outside
(*d*) fitting a long length of pipe to the inside
(*e*) all of the above.

317. When the depth of water in an open channel is greater than the critical depth then flow is said to be
(*a*) critical (*b*) turbulent
(*c*) torrential (*d*) tranquil
(*e*) sub-critical.

318. When the depth of water in an open channel is less than the critical depth, then flow is said to be
(*a*) critical (*b*) turbulent
(*c*) torrential (*d*) tranquil
(*e*) sub-critical.

319. The hydraulic grade line is
(*a*) always moving up
(*b*) always moving down
(*c*) always above the energy grade line
(*d*) the velocity head below the energy grade line
(*e*) none of the above.

320. The rise of liquid along the walls of a revolving cylinder above the initial level
(*a*) is greater than the depression of the liquid at the axis of rotation
(*b*) is lesser than the depression of the liquid at the axis of rotation
(*c*) is the same as the depression of the liquid at the axis of rotation
(*d*) it depends upon the magnitude of speed
(*e*) none of the above.

321. When a liquid rotates at constant angular velocity about a vertical axis as a rigid body, the pressure
(*a*) increases linearly as its radial distance
(*b*) varies inversely as the altitude along any vertical line
(*c*) varies as the square of the radial distance
(*d*) decreases as the square of radial distance
(*e*) none of the above.

322. Total pressure on the top of a closed cylindrical vessel completely filled with liquid, is directly proportional to
(*a*) radius (*b*) (radius)^2
(*c*) (radius)^3 (*d*) (radius)^4
(*e*) none of the above.

323. If the particles of a fluid attain such velocities that velocities vary from point to point in magnitude and direction, as well as from instant to instant, the flow is said to be
(*a*) disturbed flow (*b*) turbulent flow
(*c*) turbid flow (*d*) non-uniform flow
(*e*) non-steady flow.

324. The included angle of triangular notch for maximum discharge is
(*a*) 45° (*b*) 60°
(*c*) 90° (*d*) 108°
(*e*) 120°.

325. Most efficient channel section is
(*a*) half hexagon in form of trapezoid
(*b*) triangular
(*c*) rectangular
(*d*) semi-circular
(*e*) none of the above.

326. The discharge through a rectangular-notch weir varies as
(*a*) $H^{-1/2}$ (*b*) $H^{1/2}$
(*c*) $H^{3/2}$ (*d*) $H^{5/2}$
(*e*) H^2.

327. The discharge over a sharp-edge triangular notch having included angle of 2θ and depth of *h* is given by the formula
(*a*) $\frac{2}{3}C_d\sqrt{2g}\ \tan\theta\ h^{3/2}$ (*b*) $\frac{8}{15}C_d\sqrt{2g}\ \tan\theta\ h^{3/2}$
(*c*) $\frac{2}{3}C_d\sqrt{2g}\ \tan\theta\ h^{5/2}$ (*d*) $\frac{8}{15}C_d\sqrt{2g}\ \tan\theta\ h^{5/2}$
(*e*) none of the above.

328. The discharge in a Sultro weir varies as proportional to
(*a*) H (*b*) $H^{3/2}$
(*c*) $\sqrt{H}$ (*d*) H^2
(*e*) $H^{5/2}$.

329. The discharge through a semi-circular weir is proportional
(*a*) $H^{-1/2}$ (*b*) $H^{1/2}$
(*c*) $H^{3/2}$ (*d*) $H^{5/2}$
(*e*) H^2.

330. Critical-depth metre is used to measure
(*a*) discharge in an open channel
(*b*) hydraulic jump
(*c*) depth of flow in channel
(*d*) depth of channel
(*e*) none of the above.

331. If flow in an open channel is gradually varied, then the flow will be
(*a*) steady uniform flow
(*b*) unsteady uniform flow
(*c*) steady non-uniform flow
(*d*) unsteady non-uniform flow
(*e*) none of the above.

332. The width of the weir with end contraction is
(*a*) less than the width of channel
(*b*) more than the width of channel
(*c*) equal to width of channel
(*d*) half the width of channel
(*e*) twice the width of channel.

333. The function of surge tank is to
(*a*) relieve the pipe line of excessive pressure produced by water hammer
(*b*) moothen flow
(*c*) act as reservoir for emergency conditions
(*d*) avoid reverse flow
(*e*) supply water at constant pressure.

334. The discharge of broad crested weir is maximum if the head of water on the downstream side of weir as compared to the head on the upstream side of the weir is
(*a*) one-half (*b*) one-third
(*c*) two-third (*d*) three-fourth
(*e*) two-fifth.

335. The Cipoletti weir functions as if it were a following notch without end contractions
(*a*) triangular notch (*b*) trapezoidal notch
(*c*) rectangular notch (*d*) parallelogram notch
(*e*) none of the above.

336. Maximum discharge over broad crested weir is
(*a*) $1.71\ C_d\ L.H^{3/2}$ (*b*) $1.71\ C_d\ L.H^{5/2}$
(*c*) $1.71\ C_d\ L.H^{1/2}$ (*d*) $0.384\ C_d\ L.H^{3/2}$
(*e*) $0.384\ C_d\ L.H^{5/2}$.

337. Cipoletti notch is designed as trapezoid with its sides sloping at 1 horizontal and
(*a*) 1 vertical (*b*) 2 vertical
(*c*) 3 vertical (*d*) 4 vertical
(*e*) 5 vertical.

338. In series-pipe applications
(*a*) the head losses through each pipe are added to obtain the total head loss
(*b*) the head loss is same through each pipe
(*c*) friction factors are assumed for each pipe
(*d*) flow increases
(*e*) none of the above.

339. Choking in pipe flow implies
(*a*) no flow occurs
(*b*) negative flow takes place due to water hammer
(*c*) valve in pipeline is closed
(*d*) the specified mass flow can't occur
(*e*) no flow due to heavy pressure loss.

340. In the case of flow through parallel pipes
(*a*) flow in each pipe is same
(*b*) head loss in each pipe is same
(*c*) head loss depends upon flow conditions
(*d*) total head loss is sum of the head losses in individual pipes
(*e*) none of the above.

341. For a laminar flow
(*a*) flow occurs in a zig zag way
(*b*) Reynolds number lies between 2000 to 3000 for pipes
(*c*) Newton's law of viscosity is of importance
(*d*) pipe losses are major considerations
(*e*) velocity of flow is maximum.

342. The most economical section of circular channel for maximum discharge is obtained when
(*a*) depth of water = 0.95 d
(*b*) wetted perimeter = 2.6 d
(*c*) hydraulic mean depth = 0.29 d
(*d*) any one of the above
(*e*) none of the above
(d = dia. of circular section).

343. The flow in venturiflume takes place at
(*a*) atmospheric pressure
(*b*) at pressure greater than atmospheric pressure
(*c*) vacuum
(*d*) high pressure (*e*) any pressure.

344. Hydraulic diameter used in place of diameter for non-circular ducts is equal to
(*a*) A/m (*b*) $4\ A/m$
(*c*) $A/4\ m$ (*d*) m/A
(*e*) $4\ m/A$.
where, A = area of flow and m = perimeter

345. Any fluid flow follows
(*a*) Bernoulli's equation
(*b*) Newton's law of viscosity
(*c*) Darcy's equation (*d*) continuity equation
(*e*) all of the above.

346. The velocity distribution in the turbulent boundary layer follows
(*a*) straight line law (*b*) parabolic law
(*c*) hyperbolic law (*d*) logarithmic law
(*e*) quadratic law.

347. Laminar flow occurs in pipes, when Reynolds number
(*a*) lies between 2000—3000
(*b*) lies between 3000—4000
(*c*) is more than 2000
(*d*) is less than 2000
(*e*) none of the above.

348. Which of the following pipe bends will introduce maximum head loss ?
(*a*) 30° bend (*b*) *U*-bend
(*c*) 60° bend (*d*) 90° bend
(*e*) 45° bend.

349. In pipes larger than 25 mm, carrying water, the laminar flow
(*a*) very often exists (*b*) generally exists
(*c*) rarely exists (*d*) unpredictable
(*e*) none of the above.

350. The path of jet discharging from bottom opening in a tank full of water will be
(*a*) horizontal straight line
(*b*) linearly downward
(*c*) approximately hyperbola
(*d*) parabola with its vertex at the opening
(*e*) none of the above.

351. Borda's mouthpiece is
(*a*) a short cylindrical tube projecting inward, having length of 1/2 diameter
(*b*) a convergent tube having length of 2—3 diameters
(*c*) most commonly used (*d*) rarely used
(*e*) none of the above.

352. A hydraulic ram acts like
(*a*) a centrifugal pump (*b*) a rotary pump
(*c*) a reciprocating pump (*d*) an impulse pump
(*e*) cylinder pump.

353. Hydraulic ram is a device used
(*a*) to accelerate water flow
(*b*) lift water without electric motor
(*c*) for lifting heavy load
(*d*) beat water and lift it
(*e*) measure flow in rivers.

354. The discharge through a syphon spillway is equal to
$C_d \times a \times \sqrt{2g} \times ...$
(*a*) $\sqrt{H}$ (*b*) H
(*c*) $H^{3/2}$ (*d*) $H^{5/2}$
(*e*) H^2.

355. An air vessel is provided at the summit in the syphon in order to
(*a*) maintain pressure difference
(*b*) increase discharge
(*c*) increase velocity
(*d*) control pressure variations
(*e*) avoid interruption in the flow.

356. A fluid flow taking place continuously round a curved path about a fixed axis of rotation, is known as
(*a*) rotational flow (*b*) radial flow
(*c*) circular flow (*d*) unsteady flow
(*e*) vortex flow.

357. When a liquid rotates at constant angular velocity about a vertical axis as a rigid body, the pressure
(*a*) varies as the square of the radial distance
(*b*) decreases as the square of the radial distance
(*c*) increases linearly as the radial distance
(*d*) varies inversely as the elevation along any vertical line
(*e*) is zero throughout.

358. In a free vortex motion
(*a*) rotation of fluid, moving as a solid, takes place about an axis
(*b*) each particle moves in a circular path with a speed varying inversely as the distance from the centre
(*c*) velocity decreases with the radius
(*d*) velocity remains constant
(*e*) none of the above.

359. The critical velocity as
(*a*) maximum attainable velocity
(*b*) terminal velocity
(*c*) velocity when hydraulic jump occurs
(*d*) velocity above which the flow ceases to be streamlined
(*e*) velocity at which flow is maximum.

360. The rise of liquid along the walls of a revolving cylinder as compared to depression at the centre w.r.t. initial level is
(*a*) same (*b*) more
(*c*) less
(*d*) more/less depending on speed
(*e*) unpredictable.

361. In a forced-vortex motion
(*a*) rotation of fluid, moving as a solid, takes place about an axis
(*b*) each particle moves in a circular path with a speed varying inversely as the distance from the centre
(*c*) velocity decreases with the radius
(*d*) velocity remains constant
(*e*) none of the above.

362. When a fluid flows in concentric circles, it is known as
(*a*) free circular motion (*b*) free rotational motion
(*c*) free spiral vortex flow
(*d*) free cylindrical vortex flow
(*e*) radial flow.

363. In a free vortex motion, the tangential velocity of the water particles is proportional to
(*a*) distance from the centre (r)
(*b*) r^2 (*c*) $1/r$
(*d*) $\frac{1}{r^2}$ (*e*) $\frac{1}{\sqrt{r}}$

364. A right-circular cylinder open at top is filled with water and rotated about its vertical axis at such speed that half the liquid spills out. The pressure at centre of bottom is
(*a*) one half its value when cylinder was full
(*b*) one fourth its value when cylinder was full
(*c*) zero
(*d*) can't be determined due to insufficient data
(*e*) none of the above.

365. An ideal fluid is
(*a*) similar to perfect gas
(*b*) one which obeys Newton's law of viscosity
(*c*) frictionless and incompressible
(*d*) very viscous
(*e*) does not exist.

366. The total pressure on the top of a closed cylindrical vessel of radius r filled with liquid is proportional to
(*a*) r (*b*) $\frac{1}{r}$
(*c*) $\frac{1}{r^2}$ (*d*) r^2
(*e*) $\frac{1}{\sqrt{r}}$.

367. The general equation of continuity for three dimensional flow of a compressible fluid for steady flow is
(*a*) $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$ (u, v and w are components of velocity in x, y and z direction).
(*b*) $\frac{\partial u}{\partial x}=\frac{\partial v}{\partial y}=\frac{\partial w}{\partial z}=0$
(*c*) $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial x}=1$
(*d*) $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=u.v.w$
(*e*) none of the above.

368. Reynolds number for non-circular cross section is
(*a*) $\frac{V\,.\,4P}{\nu}$ (*b*) $\frac{V\,.\,P}{\nu}$
(*c*) $\frac{V\,.\,2P}{4\nu}$ (*d*) $\frac{V\,.\,P}{4\nu}$
(*e*) $\frac{VP}{4\nu}$
[V = mean velocity, ν = kinematic viscosity
P = Ratio of cross-sectional area to the wetted perimeter]

369. If a mouthpiece is running full at the outlet, the vacuum created at vena-contracta
(*a*) increases velocity of jet
(*b*) decreases velocity of jet
(*c*) decreases the discharge
(*d*) decreases the value of coefficient of contraction
(*e*) does not affect the velocity of jet.

370. Vertical distribution of velocity in an open channel for laminar flow can be assumed as
(*a*) logarithmic (*b*) parabolic
(*c*) straight line (constant)
(*d*) hyperbolic (*e*) none of the above.

371. Vertical distribution of velocity in an open channel for turbulent flow can be assumed as
(*a*) logarithmic (*b*) parabolic
(*c*) straight line (constant)
(*d*) hyperbolic (*e*) none of the above.

372. The most economical channel section is one for which the following parameter is maximum for a given cross sectional area
(*a*) velocity (*b*) discharge
(*c*) depth (*d*) wetted perimeter
(*e*) hydraulic radius.

373. The most economical section of a rectangular channel for maximum discharge is obtained when its depth is equal to
(*a*) half the breadth (*b*) twice the breadth
(*c*) same as the breadth (*d*) $\frac{3}{4}$th the breadth
(*e*) one third the breadth.

374. One dimensional flow is
(*a*) restricted to flow in a straight line
(*b*) uniform flow
(*c*) one which neglects changes in a transverse direction
(*d*) the most general flow
(*e*) none of the above.

375. Euler's equation for motion of liquids is based on the assumption that the
(*a*) flow is streamline
(*b*) flow takes place continuously
(*c*) flow is homogeneous and incompressible
(*d*) flow is turbulent
(*e*) flow is irrotational.

376. Euler's equation in the differential form for motion of liquids is given by
(*a*) $\frac{dp}{\rho} - gdz + vdv = 0$ (*b*) $\frac{dp}{\rho} + gdz - gdz = 0$
(*c*) $\frac{dp}{\rho} + gdz + vdv = 0$ (*d*) $\rho dp + gdz + vdv = 0$
(*e*) none of the above.

377. For an irrotational flow, $\frac{\delta^2\phi}{\delta x^2} + \frac{\delta^2\phi}{\delta y^2} = 0$ is the equation given by
(*a*) Cauchy-Riemann (*b*) Reynolds
(*c*) Laplace (*d*) Bernoulli
(*e*) Manning.

378. If u, v, w are the components of the velocity v of a moving particle, then the equation $\frac{u}{dx} = \frac{v}{dy} = \frac{w}{dz}$ represents an equation of
(*a*) one dimensional flow (*b*) two dimensional flow
(*c*) three dimensional flow
(*d*) multi dimensional flow
(*e*) none of the above.

379. In case of a two dimensional flow the components of velocity are given by $u = ax$; $v = by$, the streamlines will consist of a series of
(*a*) circular arcs (*b*) parabolic arcs
(*c*) hyperbolic arcs (*d*) elliptical arcs
(*e*) none of the above.

380. In case of a two dimensional flow, if the components of velocity are given by $u = ax$; $v = by$, the point where no motion occurs, is known as
(*a*) critical point (*b*) neutral point
(*c*) stagnation point (*d*) stationary point
(*e*) none of the above.

381. For pipe flows, at constant head, capacity is proportional to
(*a*) (pipe dia)^2 (*b*) (pipe dia)$^{2.5}$
(*c*) pipe dia (*d*) (pipe dia)^3
(*e*) 1/pipe dia.

382. For pipe flows, at constant capacity, head is proportional to
(*a*) $1/d$ (*b*) $1/d^2$
(*c*) $1/d^3$ (*d*) $1/d^5$
(*e*) $1/d^4$
(where, d = pipe diameter).

383. 10 m of water column is equal to
(*a*) 10 kN/m^2 (*b*) 1 kN/m^2
(*c*) 100 kN/m^2 (*d*) 0.1 kN/m^2
(*e*) none of the above.

384. As pump speed increases, its NPSH (net positive suction head) requirement
(*a*) increases (*b*) decreases
(*c*) remains unaffected
(*d*) may increase/decrease depending on other considerations
(*e*) none of the above.

385. For pipe flows, at constant diameter, head is proportional to
(*a*) flow (*b*) (flow)^2
(*c*) (flow)^3 (*d*) 1/flow
(*e*) 1/flow^2.

386. For pipe flow, at constant diameter, capacity is proportional to
(*a*) $\sqrt{\text{head}}$ (*b*) head
(*c*) head$^{3/2}$ (*d*) head^2
(*e*) $1/\sqrt{\text{head}}$.

387. The pressure in pipes for fluids flowing is proportional to
(*a*) $\frac{1}{\text{Inside diameter of pipe } (d)}$
(*b*) $\frac{1}{d^2}$ (*c*) $\frac{1}{d^3}$
(*d*) $\frac{1}{d^4}$ (*e*) $\frac{1}{d^5}$.

388. Friction factor for pipes depends on
(*a*) rate of flow (*b*) fluid density
(*c*) viscosity (*d*) pipe roughness
(*e*) all of the above.

389. In order to replace a compound pipe by a new pipe, the pipes will be equivalent when following are same for both the pipes
(*a*) length and flow (*b*) diameter and flow
(*c*) loss of head and flow
(*d*) length and loss of head
(*e*) loss of head and velocity.

390. The head loss in case of hot water flow through a pipe compared to cold water flow will be
(*a*) same (*b*) more
(*c*) less
(*d*) more or less depending on range of temperatures
(*e*) unpredictable.

391. The frictional resistance of a pipe varies approximately as
(*a*) velocity of flow (v) (*b*) v^2
(*c*) $\sqrt{v}$ (*d*) $v^{3/2}$
(*e*) $v^{5/2}$

392. According to Darcy's formula, loss of head due to friction in the pipe is
(*a*) $\frac{4flv^2}{gd}$ (*b*) $\frac{flv^2}{gd}$
(*c*) $\frac{2flv^2}{gd}$ (*d*) $\frac{4flv}{gd}$
(*e*) $\frac{4flv^2}{d}$.
where, f = Darcy's coefficient,
l = length of pipe,
v = velocity of liquid flow,
d = diameter of pipe.

393. If d = diameter of nozzle, D = diameter of pipe, l = length of pipe and f = Darcy's coefficient of friction for pipe, then for maximum power transmission of power, d should be equal to
(*a*) $\left(\frac{D^5}{8fl}\right)^{1/4}$ (*b*) $\left(\frac{D^5}{8fl}\right)^{1/2}$
(*c*) $\left(\frac{D^5}{8fl}\right)^{1/3}$ (*d*) $\left(\frac{D^5}{8fl}\right)^{3/4}$
(*e*) $\left(\frac{D^5}{8fl}\right)^{2/5}$.

394. To replace a pipe of diameter D by n parallel pipes of diameter d, the formula used is
(*a*) $d = \frac{D}{n}$ (*b*) $d = \frac{D}{n^{1/2}}$
(*c*) $d = \frac{D}{n^{3/2}}$ (*d*) $d = \frac{D}{n^{2/5}}$
(*e*) $d = \frac{D}{n^{2/3}}$.

395. For a flow to be rotational, the velocity normal to the plane of area should be equal to the
(*a*) angular velocity vector
(*b*) half the angular velocity vector
(*c*) twice the angular velocity vector
(*d*) zero (*e*) maximum.

396. Head loss in a flowing fluid is experienced due to
(*a*) friction at surface (*b*) change of direction
(*c*) change of section of passage
(*d*) obstruction in passage
(*e*) all of the above.

397. Loss of head due to friction in a pipe of uniform is diameter with viscous flow is equal to
(*a*) Reynolds number (Re)
(*b*) 1/Re (*c*) 4/Re
(*d*) 16/Re (*e*) 64/Re.

398. Power transmitted through a pipe is maximum when the loss of head due to friction is
(*a*) one-half of the total head supplied
(*b*) one-third of the total head supplied
(*c*) one-fourth of the total head supplied
(*d*) equal to the total head supplied
(*e*) zero.

399. If l_1, l_2, l_3 etc. be the lengths and d_1, d_2, d_3, etc. be the diameters of the parts of a compound pipe, then length L and diameter D of a uniform equivalent pipe will be related as under
(*a*) $\frac{L}{D} = \frac{l_1}{d_1} + \frac{l_2}{d_2} + \frac{l_3}{d_3} + \ldots$
(*b*) $\frac{L}{D^2} = \frac{l_1}{d_1^2} + \frac{l_2}{d_2^2} + \frac{l_3}{d_3^2} + \ldots$
(*c*) $\frac{L}{D^3} = \frac{l_1}{d_1^3} + \frac{l_2}{d_2^3} + \frac{l_3}{d_3^3} + \ldots$
(*d*) $\frac{L}{D^4} = \frac{l_1}{d_1^4} + \frac{l_2}{d_2^4} + \frac{l_3}{d_3^4} + \ldots$
(*e*) $\frac{L}{D^5} = \frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5} + \ldots$

400. Time of flow from one tank in which water level is h_1 to another tank having level h_2 will be proportional to
(*a*) $h_1 - h_2$ (*b*) $\sqrt{h_1 - h_2}$
(*c*) $\sqrt{h_1} - \sqrt{h_2}$ (*d*) $\frac{1}{\sqrt{h_1} - \sqrt{h_2}}$
(*e*) $h_1^{3/2} - h_2^{3/2}$.

401. Maximum efficiency of transmission of power through a pipe is
(*a*) 25% (*b*) 33.3%
(*c*) 50% (*d*) 66.6%
(*e*) 100%.

402. If the pressure at the inlet of a pipe is 90 kg/cm^2 and the pressure drop over the pipe line is 10 kg/cm^2, the efficiency of transmission is
(*a*) 66.6% (*b*) 77.7%
(*c*) 55.5% (*d*) 88.8%
(*e*) 44.4%

403. The hydraulic mean depth for a circular pipe of diameter 'd' running full is equal to

(*a*) d (*b*) $\frac{d}{3}$

(*c*) $\frac{d}{2}$ (*d*) $\frac{d}{4}$

(*e*) $\frac{d}{5}$.

404. Hydraulic gradient is equal to

(*a*) $\frac{\text{difference in water surface}}{\text{total length of channel}}$

(*b*) $\frac{\text{head loss due to friction}}{\text{total length of channel}}$

(*c*) $\frac{\text{wetted perimeter}}{\text{total length of channel}}$

(*d*) $\frac{\text{area of cross-section}}{\text{total length of channel}}$

(*e*) none of the above.

405. The total frictional resistance to fluid flow is independent of

(*a*) density of fluid (*b*) velocity

(*c*) pressure (*d*) surface roughness

(*e*) area of wetted surface.

406. The ratio of the hydraulic radius of a pipe running full of water to the hydraulic radius of a square section of a channel, whose side is equal to the diameter of the pipe, is

(*a*) 1 (*b*) $\frac{1}{2}$

(*c*) $\frac{1}{3}$ (*d*) $\frac{3}{4}$

(*e*) none of the above.

407. Velocity of pressure waves due to pressure disturbances imposed in a fluid is equal to

(*a*) $\sqrt{\frac{\text{Bulk modulus } (E)}{\text{density } (\rho)}}$ (*b*) $\sqrt{E\rho}$

(*c*) $\sqrt{\rho/E}$ (*d*) $\sqrt{1/\rho E}$

(*e*) none of the above.

408. The velocity of fluid particle at the centre of pipe section is

(*a*) zero (*b*) minimum

(*c*) maximum (*d*) average of full section

(*e*) some value in between minimum and maximum.

409. Steady flow occurs when

(*a*) conditions change steadily with time

(*b*) conditions do not change with time at any point

(*c*) conditions are same at adjacent points with time

(*d*) velocity vector at any point remains constant

(*e*) none of the above.

410. Uniform flow occurs when

(*a*) at every point the velocity vector is identical, in magnitude and direction, for any given instant

(*b*) the flow is steady

(*c*) discharge through a pipe is constant

(*d*) conditions do not change with time at any point

(*e*) none of the above.

411. Which of the following represents steady uniform flow?

(*a*) flow through an expanding tube at an increasing rate

(*b*) flow through an expanding tube at constant rate

(*c*) flow through a long pipe at decreasing rate

(*d*) flow through a long pipe at constant rate

(*e*) none of the above.

412. In the case of turbulent flow

(*a*) it occurs in open channel

(*b*) losses are proportional to square of velocity

(*c*) velocity at boundary is zero

(*d*) it is not possible to measure flow

(*e*) shear stresses are more compared to laminar flow.

413. For a siphon to work satisfactorily, the minimum pressure in the pipe as compared to vapour pressure of liquid should be

(*a*) more (*b*) less

(*c*) equal (*d*) could be anything

(*e*) unpredictable.

414. Water hammer in pipes occurs due to

(*a*) some one hitting the pipe with a hammer

(*b*) sudden change in the velocity of any flowing fluid

(*c*) heavy pressurisation of pipe

(*d*) obstruction in pipe

(*e*) none of the above.

415. If a liquid in a pipe suddenly undergoes a change in velocity by ΔV and if ρ is density of liquid and c is the velocity of pressure wave or speed of sound in liquid, then change in pressure experienced equals

(*a*) $\rho c/\Delta v$ (*b*) $-\Delta v/\rho c$

(*c*) $-\rho \Delta v/c$ (*d*) $-\rho/c\Delta v$

(*e*) none of the above.

416. Which of the following represents unsteady non-uniform flow ?

(*a*) flow through an expanding tube at an increasing rate

(*b*) flow through an expanding tube at constant rate

(*c*) flow through a long pipe at decreasing rate

(*d*) flow through a long pipe at constant rate

(*e*) none of the above.

417. Critical depth of a channel is equal to

(*a*) $\frac{v^2}{g}$ (*b*) $\frac{v^2}{2g}$

(*c*) $\frac{v^2}{4g}$ (*d*) $v \times g$

(*e*) $v^2 \times g$.

418. In a short cylindrical external mouthpiece, the vena-contracta occurs at a place which is at a distance equal to

(*a*) diameter of the orifice from the outlet of orifice

(*b*) one-fourth the diameter of the orifice from the outlet of orifice
(*c*) one-third the diameter of the orifice from the outlet of orifice
(*d*) two-third the diameter of the orifice from the outlet of orifice
(*e*) none of the above.

419. Fire hose nozzle is generally made of
(*a*) divergent shape (*b*) convergent shape
(*c*) convergent-divergent shape
(*d*) cylindrical shape
(*e*) parabolic shape.

420. Chezy's equation is used to determine
(*a*) velocity of flow in open channel
(*b*) velocity of flow in pipe
(*c*) flow over weirs
(*d*) discharge through notch
(*e*) flow through mouthpiece.

421. Equation of continuity results from the principal of conservation of
(*a*) energy (*b*) flow
(*c*) mass (*d*) momentum
(*e*) entropy.

422. Hydraulic grade line for any flow system as compared to energy line is
(*a*) above (*b*) below
(*c*) at same level
(*d*) may be below or above depending upon velocity of flow
(*e*) none of the above.

423. The cause of turbulence in fluid flow may be
(*a*) high velocity gradient
(*b*) high Reynolds number
(*c*) discontinuity in velocity distribution
(*d*) high friction and stress in flow

424. The magnitude of water hammer depends on
(*a*) length of pipe
(*b*) elastic properties of pipe material
(*c*) rate of stoppage of flow
(*d*) all of the above
(*e*) none of the above.

425. The magnitude of water hammer does not depend upon
(*a*) temperature of fluid
(*b*) length of pipe
(*c*) elastic properties of pipe material
(*d*) time of valve closure
(*e*) rate of stoppage of flow.

426. Which of the following represents unsteady uniform flow ?
(*a*) flow through an expanding tube at an increasing rate
(*b*) flow through an expanding tube at constant rate
(*c*) flow through a long pipe at decreasing rate
(*d*) flow through a long pipe at constant rate
(*e*) all of the above.

427. A weir in which the downstream water level of the weir nappe is higher than the crest, is called
(*a*) submerged weir (*b*) overflowing weir
(*c*) broadcrested wear (*d*) cipoletti weir
(*e*) ogee weir.

428. Discharge through a totally submerged orifice is directly proportional to
(*a*) the difference in elevation of water surface
(*b*) the square root of the difference in elevation of water surface
(*c*) the square root of the area of the opening
(*d*) reciprocal of the area of the opening
(*e*) none of the above.

429. The upper surface of the weir over which water flows, is known as
(*a*) vein (*b*) nappe
(*c*) sill (*d*) weir top surface
(*e*) none of the above.

430. Which of the following represents steady non-uniform flow ?
(*a*) flow through an expanding tube at an increasing rate
(*b*) flow through an expanding tube at constant rate
(*c*) flow through a long pipe at decreasing rate
(*d*) flow through a long pipe at a constant rate
(*e*) none of the above.

431. Drag is defined as the force component exerted on an immersed object, the component acting in direction
(*a*) normal to flow direction
(*b*) parallel to flow direction
(*c*) at resultant angle
(*d*) radial to flow direction
(*e*) opposite to flow direction.

432. Pressure drag as per boundary layer theory is function of
(*a*) shape of body (*b*) dimensions of body
(*c*) flow direction (*d*) separation of flow
(*e*) shape of body and separation of flow.

433. Profile drag is equal to
(*a*) friction drag – pressure drag
(*b*) pressure drag – friction drag
(*c*) pressure drag + friction drag
(*d*) pressure drag × friction drag
(*e*) $\dfrac{\text{pressure drag} + \text{friction drag}}{2}$

434. Bluff body is the body of such a shape that pressure drag as compared to friction drag is
(*a*) same (*b*) more
(*c*) less (*d*) zero
(*e*) negligible.

435. A body is said to be provided optimum amount of streamlining when
(*a*) friction drag is minimum
(*b*) pressure drag is minimum

(*c*) profile drag (*i.e.*, sum of friction drag and pressure drag) is minimum
(*d*) product of friction and pressure drag is minimum
(*e*) friction drag is minimum and pressure drag is maximum.

436. The flow of any fluid, real or ideal, must fulfill the following
(*a*) Newton's law of viscosity
(*b*) Newton's second law of viscosity
(*c*) Velocity at boundary must be zero relative to the boundary
(*d*) the continuity equation
(*e*) none of the above.

437. Turbulent flow generally occurs for cases involving
(*a*) very slow motions (*b*) very viscous fluids
(*c*) very narrow passages (*d*) all of the above
(*e*) none of the above.

438. In turbulent flow
(*a*) the shear stresses are generally larger than in a similar laminar flow
(*b*) fluid particles move in an orderly manner
(*c*) momentum transfer is on a molecular scale only
(*d*) cohesion is more effective than momentum transfer in causing shear stress
(*e*) none of the above.

439. In laminar flow
(*a*) the velocity is no consideration
(*b*) Newton's law of viscosity applies
(*c*) losses are proportional to square of velocity
(*d*) generally occurs in practice
(*e*) rarely occurs.

440. Continuity equation can take the form
(*a*) $Q = pV\nu$ (*b*) $\rho_1 A_1 = \rho_2 A_2$
(*c*) $A_1 \nu_1 = A_2 \nu_2$ (*d*) $p_1 A_1 \nu_1 = p_2 A_2 \nu_2$
(*e*) all of the above.

441. The continuity equation
(*a*) requires that Newton's second law of motion be satisfied at every point in fluid
(*b*) relates the momentum per unit volume for two points on a streamline
(*c*) expresses the relation between energy and work
(*d*) relates mass rate of flow along a streamline
(*e*) none of the above.

442. Continuity equation relates
(*a*) conservation of mass and momentum
(*b*) energy and work
(*c*) frictional losses
(*d*) mass rate of flow along a streamline
(*e*) shear stress in turbulent flow.

443. The continuity equation in fluid flow
(*a*) states that energy is constant along a streamline
(*b*) states that energy is constant everywhere in the fluid
(*c*) applies to irrotational flow only
(*d*) states that the net rate of inflow into small volume must be zero
(*e*) none of the above.

444. Head loss in turbulent flow in a pipe
(*a*) varies directly as velocity
(*b*) varies inversely as square of velocity
(*c*) varies approximately as square of velocity
(*d*) depends upon orientation of pipe
(*e*) varies inversely as velocity.

445. The losses in open channel vary as proportional to
(*a*) velocity (V) (*b*) V^2
(*c*) $\sqrt{V}$ (*d*) V^3
(*e*) $\frac{1}{\sqrt{V}}$.

446. The losses due to sudden expansion are expressed by
(*a*) $\frac{V_1^2 - V_2^2}{2g}$ (*b*) $\frac{V_2^2 - V_1^2}{2g}$
(*c*) $\frac{(V_1 - V_2)^2}{g}$ (*d*) $\frac{(V_1 - V_2)^2}{2g}$
(*e*) $\frac{0.5V_1^2}{2g}$

447. The losses due to sudden contraction are expressed by
(*a*) $\frac{V_1^2 - V_2^2}{2g}$ (*b*) $\frac{V_2^2 - V_1^2}{2g}$
(*c*) $\frac{(V_1 - V_2)^2}{g}$ (*d*) $\frac{(V_1 - V_2)^2}{2g}$
(*e*) $\frac{0.5V_1^2}{2g}$.

448. The depth of water below the spillway and after hydraulic jump are 1 m and 6 m respectively. The head lost will be
(*a*) 1.04 m (*b*) 5 m
(*c*) 1.7 m (*d*) 2.05 m
(*e*) none of the above.

449. The velocity distribution for flow between two fixed parallel plates
(*a*) it constant over the cross-section
(*b*) is zero at the plates and increases linearly to the midplane
(*c*) varies parabolically across the section
(*d*) is zero in middle and increases linearly towards the plates
(*e*) none of these.

450. Bernoulli's theorem is applicable for
(*a*) streamline flow (*b*) steady flow
(*c*) turbulent flow (*d*) normal flow
(*e*) perfect incompressible fluid flowing in continuous streams.

451. The shear stress in a fluid flowing in a round pipe
(*a*) is constant over the cross-section
(*b*) is zero at the wall and increases linearly to the centre

(*c*) is zero at centre and varies linearly with radius
(*d*) varies parabolically across the section
(*e*) unpredictable.

452. Which one is the correct statement ?
(*a*) Hydraulic grade line should always be above the centre line of conduit
(*b*) Hydraulic grade line should always be below the centre line of conduit
(*c*) Hydraulic grade line should always the parallel to the centre line of conduit
(*d*) Hydraulic grade line may be above or below the centre line of conduit
(*e*) none of the above.

453. A liquid jet from a nozzle exposed to atmosphere traverses along
(*a*) a straight line (*b*) a circular path
(*c*) an elliptical path (*d*) parabolic path
(*e*) hyperbolic path.

454. In laminar flow through a round tube, the discharge varies
(*a*) linearly as the viscosity
(*b*) inversely as the pressure drop
(*c*) as the cube of the diameter
(*d*) inversely as the viscosity
(*e*) directly as the static head.

455. If ρ is density of fluid, then pressure of fluid due to water hammer is directly proportional to
(*a*) ρ (*b*) $\frac{1}{\sqrt{\rho}}$
(*c*) $\sqrt{\rho}$ (*d*) ρ^2
(*e*) $\frac{1}{\rho^2}$.

456. The magnitude of rise of pressure due to water hammer in a rigid and non-elastic pipe carrying water of density ρ and bulk modules k will be equal to
(*a*) $\sqrt{\frac{k}{\rho}}$ (*b*) $\sqrt{kp}$
(*c*) $\sqrt{\frac{\rho}{k}}$ (*d*) $\frac{k}{\rho}$
(*e*) $k\rho$.

457. Separation occurs when
(*a*) the velocity of sound is reached
(*b*) the boundary layer comes to rest
(*c*) the cross-section of a channel is reduced
(*d*) the pressure reaches a minimum
(*e*) all of the above.

458. The value of coefficient of velocity compared to coefficient of discharge
(*a*) is less (*b*) is more
(*c*) has no relation (*d*) is same
(*e*) none of the above.

459. The hydraulic radius is given by
(*a*) wetted perimeter divided by area
(*b*) area divided by square of wetted perimeter
(*c*) area divided by wetted perimeter
(*d*) square root of area (*e*) none of the above.

460. Pick up the correct statement
(*a*) venturimeter is more accurate than nozzle
(*b*) nozzle has same accuracy as venturi, but pressure loss is more and the cost is low
(*c*) pressure loss in both is same
(*d*) venturimeter has no restriction on availability of straight length
(*e*) nozzle has no restriction on availability of straight length.

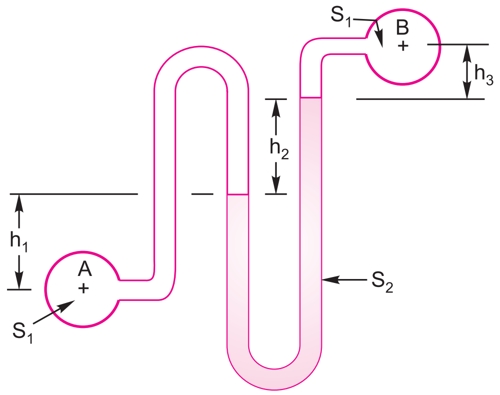
461. Rotameter is used to measure
(*a*) rotation (*b*) flow
(*c*) pressure (*d*) velocity
(*e*) viscosity.

462. The most economical section of a trapezoidal channel for maximum discharge is obtained when
(*a*) hydraulic depth = half of depth
(*b*) half of top width = sloping side
(*c*) length at perpendiculars from centre of top width to bottom and sloping sides are equal
(*d*) all of the above (*e*) none of the above.

463. When venturimeter is inclined, then for a given flow it will show
(*a*) less reading (*b*) more reading
(*c*) same reading (*d*) inaccurate reading
(*e*) erroneous reading.

464. The vertical component of force on a curved surface submerged in a static liquid is equal to the
(*a*) mass of the liquid above the curved surface
(*b*) weight of the liquid above the curved surface
(*c*) product of pressure of C.G. multiplied by the area of the curved surface
(*d*) product of pressure at C.G. multiplied by the projected area of the curved surface.

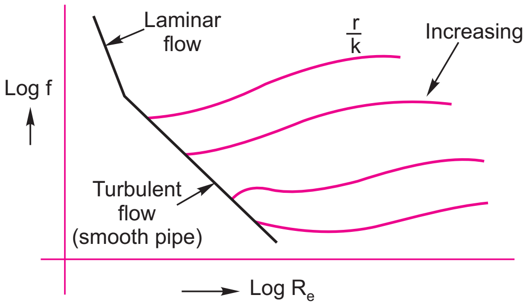
465. Two pipe lines at different pressures, p_A and p_B, each carrying the same liquid at specific gravity S_1, are connected to a U-tube with a liquid of specific gravity S_2 resulting in the level differences h_1, h_2 and h_3 as shown in the figure below. The difference in pressure head between points A and B in terms of head of water is



(*a*) $h_1S_2 + h_2S_1 + h_3S_1$ (*b*) $h_1S_1 + h_2S_2 - h_3S_1$
(*c*) $h_1S_1 - h_2 S_2 - h_3S_1$ (*d*) $h_1S_1 + h_2S_2 + h_3S_1$.

466. In a rough turbulent flow in a pipe, the friction factor would depend upon

(*a*) velocity of flow (*b*) pipe diameter
(*c*) type of fluid flowing (*d*) pipe condition and pipe diameter.



467. In turbomachinery, the relevant parameters are volume flow rate, density, viscosity, bulk modulus, pressure difference, power consumption, rotational speed and a characteristic dimension. According to Buckingham pi (π) theorem, the number of independent non-dimensional groups for this case is

(*a*) 3 (*b*) 4
(*c*) 5 (*d*) 6

468. List I gives 4 dimensionless numbers and List II gives the type of forces which are one of the constitutents describing the numbers. Match List I with List II and select the correct answer using the codes given below the lists :

List I	List II
A. Euler number	1. Pressure force
B. Froude number	2. Gravity force
C. Mach number	3. Viscous force
D. Webber number	4. Surface-tension
	5. Elastic force

Codes:	*A*	*B*	*C*	*D*
(*a*)	2	3	4	5
(*b*)	3	2	4	5
(*c*)	2	1	3	4
(*d*)	1	2	5	4

469. In a pipe flow, the head lost due to friction of 6 m. If the power transmitted through the pipe has to be the maximum, then the total head at the inlet of the pipe will have to be maintained at

(*a*) 36 m (*b*) 30 m
(*c*) 24 m (*d*) 18 m.

470. If H is the total head at inlet and h_1 is the head lost due to friction, efficiency of power transmission through a straight pipe is given by

(*a*) $(H - h_1)/H$ (*b*) $H/(H + h_1)$
(*c*) $(H - h_1)/(H + h_1)$ (*d*) $H/(H - h_1)$.

471. A dimensionless group formed with the variables ρ (density), ω (angular velocity), μ (dynamic viscosity) and D (characteristic diameter) is

(*a*) $\rho\omega\mu/D^2$ (*b*) $\rho\omega D^2/\mu$
(*c*) $\rho\omega\mu D^2$ (*d*) $\rho\omega\mu D$.

472. The following terms relate to floating bodies:

Centre of gravity ... G
Meta centre ... M
Weight of floating body ... W
Buoyant force ... F_B

Match List I with List II and select these correct answer.

List I (Condition)	List II (Result)
A. G is above M	1. Stable equilibrium
B. G and M coincide	2. Unstable equilibrium
C. G is below M	3. Floating body
D. $F_B \geq W$	4. Neutral equilibrium

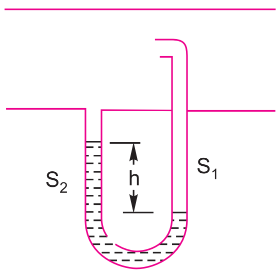
Codes:	*A*	*B*	*C*	*D*
(*a*)	1	3	2	4
(*b*)	3	1	4	2
(*c*)	2	3	4	1
(*d*)	2	4	1	3

473. For fully developed laminar flow through a pipe the volumetric flow is given by (symbols have the usual meaning)

(*a*) $\dfrac{\pi}{8\mu}R^4\left(-\dfrac{dp}{dz}\right)$ (*b*) $\dfrac{\pi}{4\mu}\left(-\dfrac{dp}{dz}\right)$

(*c*) $\dfrac{\pi}{32\mu}R^4\left(-\dfrac{dp}{dz}\right)$ (*d*) $\dfrac{\pi}{16\mu}R^4\left(-\dfrac{dp}{dz}\right)$.

474. A Prandtl Pitot tube was used to measure the velocity of a fluid of specific gravity S_1. The differential manometer, with a fluid of specific gravity S_2, connected to the Pitot tube recorded a level difference as h. The velocity V is given by the expression.



(*a*) $\sqrt{2gh(S_1/S_2 - 1)}$ (*b*) $\sqrt{2gh(S_2/S_1 - 1)}$
(*c*) $\sqrt{2gh(S_1 - S_2)}$ (*d*) $\sqrt{2gh(S_2 - S_1)}$.

475. The expression $(p + \rho gz + \rho v^2/2)$ commonly used to express Bernoulli's equation, has units of

(*a*) total energy per unit mass
(*b*) total energy per unit weight
(*c*) total energy per unit volume
(*d*) total energy per unit cross-sectional area of flow.

476. Match List I with List II and select the correct answer.

List I *(Properties of fluids)*	**List II** *(Definition / Results)*
A. Ideal fluid	1. Viscosity does not change with rate of deformation
B. Newtonian fluid	2. Fluid of zero viscosity
C. μ/p	3. Dynamic viscosity
D. Mercury in glass	4. Capillary depression
	5. Kinematic viscosity
	6. Capillary rise.

Codes:	*A*	*B*	*C*	*D*
(*a*)	1	2	4	6
(*b*)	1	2	3	4
(*c*)	2	1	3	6
(*d*)	2	1	5	4

477. List I gives the different items related to a boundary layer while List II gives the mathematical expressions. Match List I with List II and select the correct answer using the codes given below the lists: (symbols have the usual meaning).

List I	**List II**
A. Boundary layer thickness	1. $y = \delta, u = 0.99\, U_\infty$
B. Displacement thickness	2. $\int_0^\delta \left(1 - \frac{u}{U_\infty}\right) dy$
C. Momentum thickness	3. $\int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u}{U_\infty}\right) dy$
D. Energy thickness	4. $\int_0^\delta \frac{u}{U_\infty}\left(1 - \frac{u^2}{U_\infty^2}\right) dy$

Codes :	*A*	*B*	*C*	*D*
(*a*)	1	2	3	4
(*b*)	2	1	4	3
(*c*)	2	1	3	4
(*d*)	1	2	4	3

478. A laminar boundary layer occurs over a flat plate at zero incidence to the flow. The thickness of boundary layer at a section 2 m from the leading edge is 2 mm. The thickness of boundary layer at a section 4 m from the leading edge will be

(*a*) $2 \times (2)^2$ mm (*b*) $2 \times (2)^{1/2}$ mm
(*c*) $2 \times (2)^{4/5}$ mm (*d*) $2 \times (2)^{1/5}$ mm.

479. The model of a propeller, 3 m in diameter, cruising at 10 m/s in air, is tested in a wind tunnel on a 1 : 10 scale model. If a thrust of 50 N is measured on the model at 5 m/s wind speed, then the thrust on the prototype will be

(*a*) 20,000 N (*b*) 2,000 N
(*c*) 500 N (*d*) 200 N.

480. For solid sphere falling vertically downwards under gravity in a viscous fluid, the terminal velocity, V_1 varies with diameter '*D*' of the sphere as

(*a*) $V_1 \propto D^{1/2}$ for all diameters
(*b*) $V_1 \propto D^2$ for all diameters
(*c*) $V_1 \propto D^{1/2}$ for large *D* and $V_1 \propto D^2$ for small *D*
(*d*) $V_1 \propto D^2$ for large *D* and $V_1 \propto D^{1/2}$ for small *D*.

481. In the region of the boundary layer nearest to the wall where velocity is not equal to zero, the viscous forces are

(*a*) of the same order of magnitude as the inertial forces.
(*b*) more than inertial forces.
(*c*) less than inertial forces
(*d*) negligible.

482. Which one of the following statements is correct ?
Hydrodynamic entrance length for

(*a*) laminar flow is greater than that for turbulent flow.
(*b*) turbulent flow is greater than that for laminar flow.
(*c*) laminar flow is equal to that for turbulent flow.
(*d*) a given flow can be determined only if the Prandtl number is known.

483. Match List I with List II and select the correct :

List I	**List II**
A. Reynolds number	1. Film coefficient, pipe diameter, thermal conductivity
B. Prandtl number	2. Flow velocity, acoustic velocity
C. Nusselt number	3. Heat capacity, dynamic viscosity, thermal conductivity.
D. Mach number	4. Flow velocity, pipe diameter, kinematic viscosity.

Codes:	*A*	*B*	*C*	*D*
(*a*)	4	1	3	2
(*b*)	4	3	1	2
(*c*)	2	3	1	4
(*d*)	2	1	3	4

484. A rectangular water tank, full to the brim, has its length, breadth and height in the ratio of 2 : 1 : 2. The ratio of hydrostatic forces at the bottom to that at any larger vertical surface is

(*a*) 1/2 (*b*) 1
(*c*) 2 (*d*) 4.

485. Match List I (fluid properties) with List II (related terms) and select the correct answer.

List I	**List II**
A. Capillarity	1. Cavitation
B. Vapour pressure	2. Density of water.
C. Viscosity	3. Shear forces.
D. Specific gravity	4. Surface tension.

Codes:	*A*	*B*	*C*	*D*
(*a*)	1	4	2	3
(*b*)	1	4	3	2
(*c*)	4	1	2	3
(*d*)	4	1	3	2

486. Match List I with List II and select the correct answer :

List I *(Predominant force)*	List II *(Dimensionless numbers)*
A. Compressibility force	1. Euler number.
B. Gravity force	2. Prandtl number
C. Surface tension force	3. Mach number
D. Viscous force	4. Reynolds number.
	5. Weber number.

Codes:	*A*	*B*	*C*	*D*
(*a*)	1	2	3	4
(*b*)	3	2	5	4
(*c*)	3	1	4	5
(*d*)	2	3	5	1

487. In the context of performance evaluation of I.C. Engine, match List I with List II and select the correct answer.

List I *(Parameter)*	List II *(Equipment for measurement)*
A. Brake power (B.H.P.)	1. Bomb calorimeter.
B. Engine speed	2. Electrical tachometer.
C. Calorific value of fuel	3. Hydraulic dynamometer
D. Exhaust emissions	4. Flame ionisation detector.

Codes:	*A*	*B*	*C*	*D*
(*a*)	3	1	2	4
(*b*)	4	2	1	3
(*c*)	3	2	1	4
(*d*)	2	3	4	1

488. A large metacentric height in a vessel
(*a*) improves stability and makes periodic time to oscillation longer
(*b*) impairs stability and makes periodic time of oscillation shorter
(*c*) has no effect on stability or the periodic time of oscillation.
(*d*) improves stability and makes the periodic time of oscillation shorter.

489. For an irrotational flow, the velocity potential lines and the streamlines are always
(*a*) parallel to each other (*b*) coplanar
(*c*) orthogonal to each other
(*d*) inclined to the horizontal.

490. Match List-I with List-II and select the correct answer using the codes given below the Lists:

List-I *(Measuring device)*	List-II *(Parameter measured)*
A. Anemometer	1. Flow rate
B. Piezometer	2. Velocity
C. Pitot tube	3. Static pressure
D. Orifice	4. Difference between static and stagnation pressure

Codes:	*A*	*B*	*C*	*D*
(*a*)	1	3	4	2
(*b*)	1	2	3	4
(*c*)	2	3	4	1
(*d*)	2	4	3	1

491. Flow separation is caused by
(*a*) reduction of pressure to local vapour pressure
(*b*) a negative pressure gradient.
(*c*) a positive pressure gradient.
(*d*) thinning of boundary layer thickness to zero.

492. The normal stress is the same in all directions at a point in a fluid only when
(*a*) the fluid is frictionless.
(*b*) the fluid is frictionless and incompressible.
(*c*) the fluid has zero viscosity and is at rest.
(*d*) one fluid layer has no motion relative to an adjacent layer.

493. A house-top water tank is made of flat plates and is full to the brim. Its height is twice that of any side. The ratio of force on the bottom of the tank to that on any side will be
(*a*) 4 (*b*) 2
(*c*) 1 (*d*) 1/2.

494. A right-circular cylinder, open at the top is filled with liquid of relative density 1.2. It is rotated about its vertical axis at such a speed that half the liquid spills out. The pressure at the centre of the bottom will be
(*a*) zero
(*b*) one-fourth of the value when the cylinder was full
(*c*) half of the value when the cylinder was full
(*d*) not determinable from the given data.

495. Match List-I with List-II regarding a body partly submerged in a liquid and select the correct answer using the codes given below the lists :

List-I	List-II
A. Centre of pressure	1. Point of application of the weight of displaced liquid
B. Centre of gravity	2. Point about which the body starts oscillating when tilted by a small angle
C. Centre of buoyancy	3. Point of application of hydrostatic force
D. Metacentre	4. Point of application of the weight of the body

Codes :	*A*	*B*	*C*	*D*
(*a*)	4	3	1	2
(*b*)	4	3	2	1
(*c*)	3	4	1	2
(*d*)	3	4	2	1

496. A bucket of water hangs with a spring balance. If an iron piece is suspended into water from another support without touching the sides of the bucket, the spring balance will show

(*a*) an increased reading
(*b*) a decreased reading
(*c*) no change in reading
(*d*) increased or decreased reading depending on the depth of immersion.

497. If the surface tension of water-air interface is 0.073 N/m, the gauge pressure inside a rain drop of 1 mm diameter will be

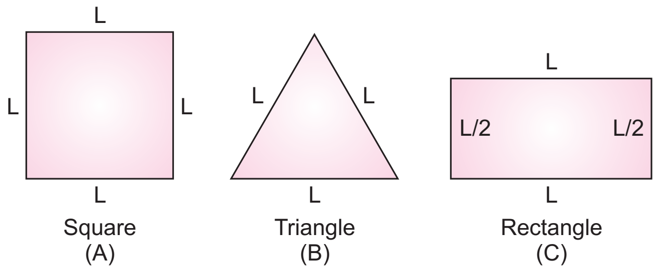
(*a*) 0.146 N/m^2 (*b*) 73 N/m^2
(*c*) 146 N/m^2 (*d*) 292 N/m^2.

498. The velocity in laminar flow becomes equal to the average velocity at following radius from the centre of a pipe (of radius r_0)

(*a*) $r_0/2$ (*b*) $r_0/\sqrt{2}$
(*c*) $r_0/\sqrt{3}$ (*d*) $2r_0/\sqrt{3}$.

499. Fig. below shows three pipes. The equivalent diameters of these pipes in descending order will be

(*a*) $B > C > A$ (*b*) $B > A > C$
(*c*) $A > B > C$ (*d*) $A > C > B$.



500. A large stone weights 100 kg in air, and when it is immersed in water, it weights 60 kg. Its specific weight is

(*a*) 1500 kg/m^3 (*b*) 2000 kg/m^3
(*c*) 2500 kg/m^3 (*d*) 3000 kg/m^3.

501. It is desired to predict the pressure drop in a large air duct. A model is constructed with linear dimensions one-tenth those of the prototype, and water is used as the test fluid. If water is 1000 times denser than air and has 100 times the viscosity of air, determine the pressure drop in the prototype for the condition corresponding to a pressure drop of 1 kg/cm^2 in the model.

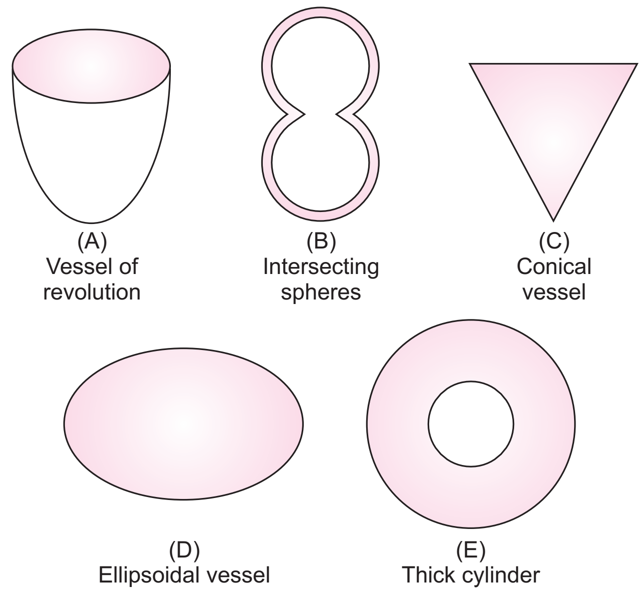
(*a*) 0.001 kg/cm^2 (*b*) 0.01 kg/cm^2
(*c*) 0.1 kg/cm^2 (*d*) 10 kg/cm^2.

502. A model of the hull of a ship is to be constructed to determine the drag characteristics of the ship in a towing tank. If the hull model is made 3 m long and ship is taken to be 300 m long, at what speed the model be operated to obtain data for ship operating at 100 km/hr.

Towing tank is filled with sea water compared to prototype mode. The speed and force on model will be

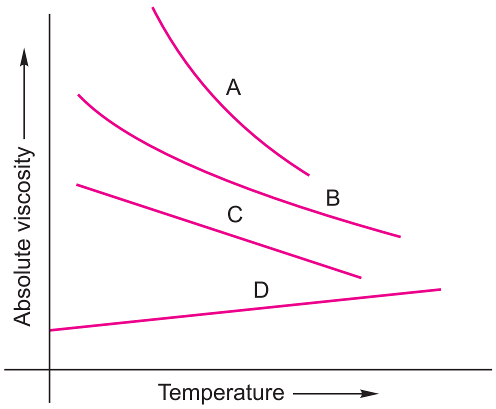
(*a*) 0.01, 10^{-4} (*b*) 0.1, 10^{-5}
(*c*) 0.1, 10^{-6} (*d*) 0.01, 10^{-6}.

503. In the design of deep-diving submersibles, the major requirements are minimum weight for buoyancy and maximum strength for pressure. The ideal choice for this purpose would be as per following part of Fig. below.



(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) *E*.

504. Fig. below shows the relative values of absolute viscosity of some important liquids/gases and how these vary with temperature. The curves applicable for air, glycerin, crude oil and water respectively are



(*a*) *D*, *A*, *B*, *C* (*b*) *C*, *B*, *A*, *D*
(*c*) *A*, *D*, *B*, *C* (*d*) *B*, *C*, *D*, *A*
(*e*) *D*, *A*, *C*, *B*.

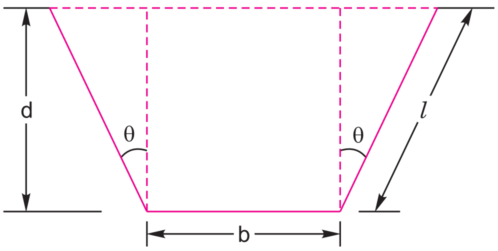
505. A channel is 4 m wide and 2 m deep. The rate of flow is 20 m^3/sec. The flow is

(*a*) subcritical (*b*) critical
(*c*) supercritical (*d*) data is insufficient.

506. If the depth of flow over a *V*-notch is doubled, the flow will increase

(*a*) 2 times (*b*) 4 times
(*c*) 4.8 times (*d*) 5.6 times.

507.



A trapezoidal open channel has the cross-section as shown in the given Fig. above. In order to have maximum hydraulic efficiency, the hydraulic radius, R and the length of the side, l should be.

(*a*) $\frac{d}{4}$ and $\frac{2}{\sqrt{3}}$ d respectively

(*b*) $\frac{d}{4}$ and $\frac{\sqrt{2}}{3}$ d respectively

(*c*) $\frac{d}{2}$ and $\frac{2}{\sqrt{3}}$ d respectively

(*d*) $\frac{d}{2}$ and $\frac{\sqrt{2}}{3}$ d respectively.

ANSWERS

1. (*d*)	**2.** (*c*)	**3.** (*d*)	**4.** (*d*)	**5.** (*e*)	**6.** (*d*)	**7.** (*e*)	**8.** (*c*)
9. (*e*)	**10.** (*c*)	**11.** (*d*)	**12.** (*d*)	**13.** (*e*)	**14.** (*b*)	**15.** (*c*)	**16.** (*c*)
17. (*a*)	**18.** (*d*)	**19.** (*c*)	**20.** (*d*)	**21.** (*d*)	**22.** (*e*)	**23.** (*e*)	**24.** (*a*)
25. (*d*)	**26.** (*a*)	**27.** (*e*)	**28.** (*d*)	**29.** (*d*)	**30.** (*a*)	**31.** (*b*)	**32.** (*c*)
33. (*c*)	**34.** (*a*)	**35.** (*a*)	**36.** (*b*)	**37.** (*d*)	**38.** (*e*)	**39.** (*d*)	**40.** (*c*)
41. (*a*)	**42.** (*a*)	**43.** (*b*)	**44.** (*b*)	**45.** (*e*)	**46.** (*c*)	**47.** (*d*)	**48.** (*b*)
49. (*a*)	**50.** (*a*)	**51.** (*a*)	**52.** (*a*)	**53.** (*b*)	**54.** (*d*)	**55.** (*d*)	**56.** (*c*)
57. (*b*)	**58.** (*d*)	**59.** (*a*)	**60.** (*c*)	**61.** (*a*)	**62.** (*c*)	**63.** (*d*)	**64.** (*d*)
65. (*b*)	**66.** (*d*)	**67.** (*c*)	**68.** (*c*)	**69.** (*a*)	**70.** (*c*)	**71.** (*c*)	**72.** (*b*)
73. (*c*)	**74.** (*b*)	**75.** (*d*)	**76.** (*c*)	**77.** (*b*)	**78.** (*d*)	**79.** (*c*)	**80.** (*a*)
81. (*a*)	**82.** (*c*)	**83.** (*c*)	**84.** (*c*)	**85.** (*b*)	**86.** (*c*)	**87.** (*b*)	**88.** (*e*)
89. (*d*)	**90.** (*c*)	**91.** (*b*)	**92.** (*c*)	**93.** (*a*)	**94.** (*c*)	**95.** (*b*)	**96.** (*c*)
97. (*a*)	**98.** (*c*)	**99.** (*d*)	**100.** (*c*)	**101.** (*d*)	**102.** (*a*)	**103.** (*a*)	**104.** (*b*)*
105. (*d*)	**106.** (*b*)	**107.** (*d*)	**108.** (*c*)	**109.** (*d*)	**110.** (*b*)	**111.** (*e*)	**112.** (*e*)
113. (*c*)*	**114.** (*e*)	**115.** (*b*)	**116.** (*e*)	**117.** (*a*)	**118.** (*c*)	**119.** (*b*)	**120.** (*a*)
121. (*d*)	**122.** (*c*)	**123.** (*d*)	**124.** (*d*)	**125.** (*c*)	**126.** (*a*)	**127.** (*b*)	**128.** (*a*)
129. (*d*)	**130.** (*b*)	**131.** (*a*)	**132.** (*c*)	**133.** (*b*)	**134.** (*c*)	**135.** (*c*)	**136.** (*a*)
137. (*b*)	**138.** (*c*)	**139.** (*a*)	**140.** (*d*)	**141.** (*a*)	**142.** (*b*)	**143.** (*d*)*	**144.** (*c*)
145. (*c*)	**146.** (*e*)	**147.** (*a*)	**148.** (*a*)	**149.** (*a*)	**150.** (*a*)	**151.** (*d*)	**152.** (*b*)
153. (*b*)	**154.** (*d*)	**155.** (*b*)	**156.** (*d*)	**157.** (*d*)	**158.** (*d*)	**159.** (*d*)	**160.** (*d*)
161. (*d*)	**162.** (*d*)	**163.** (*c*)*	**164.** (*e*)	**165.** (*a*)*	**166.** (*a*)	**167.** (*e*)	**168.** (*d*)
169. (*a*)	**170.** (*e*)	**171.** (*c*)	**172.** (*c*)	**173.** (*d*)	**174.** (*b*)	**175.** (*d*)	**176.** (*d*)
177. (*b*)	**178.** (*c*)	**179.** (*c*)	**180.** (*c*)	**181.** (*b*)	**182.** (*b*)	**183.** (*b*)	**184.** (*e*)
185. (*a*)	**186.** (*d*)	**187.** (*c*)	**188.** (*d*)	**189.** (*a*)	**190.** (*d*)	**191.** (*c*)	**192.** (*c*)
193. (*e*)	**194.** (*b*)	**195.** (*c*)	**196.** (*d*)	**197.** (*b*)	**198.** (*a*)	**199.** (*e*)	**200.** (*c*)
201. (*b*)	**202.** (*d*)	**203.** (*b*)	**204.** (*e*)	**205.** (*a*)	**206.** (*b*)	**207.** (*e*)	**208.** (*c*)
209. (*d*)	**210.** (*b*)	**211.** (*d*)	**212.** (*c*)	**213.** (*d*)	**214.** (*a*)	**215.** (*c*)*	**216.** (*b*)*
217. (*c*)	**218.** (*c*)	**219.** (*c*)	**220.** (*d*)	**221.** (*a*)	**222.** (*d*)	**223.** (*c*)	**224.** (*d*)
225. (*d*)	**226.** (*c*)	**227.** (*c*)	**228.** (*a*)	**229.** (*c*)	**230.** (*d*)	**231.** (*d*)	**232.** (*a*)
233. (*c*)	**234.** (*d*)	**235.** (*b*)	**236.** (*a*)	**237.** (*e*)	**238.** (*a*)	**239.** (*a*)	**240.** (*d*)
241. (*e*)	**242.** (*d*)	**243.** (*e*)	**244.** (*a*)	**245.** (*c*)	**246.** (*c*)	**247.** (*a*)	**248.** (*d*)
249. (*a*)	**250.** (*b*)	**251.** (*d*)	**252.** (*c*)	**253.** (*a*)	**254.** (*d*)	**255.** (*a*)	**256.** (*a*)
257. (*a*)	**258.** (*c*)	**259.** (*a*)	**260.** (*b*)	**261.** (*d*)	**262.** (*b*)	**263.** (*b*)	**264.** (*a*)
265. (*b*)	**266.** (*c*)	**267.** (*e*)	**268.** (*a*)	**269.** (*d*)	**270.** (*d*)	**271.** (*b*)	**272.** (*a*)
273. (*e*)	**274.** (*e*)	**275.** (*b*)	**276.** (*d*)	**277.** (*b*)	**278.** (*d*)	**279.** (*b*)	**280.** (*d*)
281. (*c*)	**282.** (*c*)	**283.** (*a*)	**284.** (*a*)	**285.** (*b*)	**286.** (*d*)	**287.** (*a*)	**288.** (*d*)
289. (*d*)	**290.** (*a*)	**291.** (*e*)	**292.** (*c*)	**293.** (*a*)	**294.** (*b*)	**295.** (*e*)	**296.** (*c*)
297. (*d*)	**298.** (*b*)	**299.** (*d*)	**300.** (*b*)	**301.** (*a*)	**302.** (*a*)	**303.** (*d*)	**304.** (*e*)
305. (*e*)	**306.** (*d*)	**307.** (*e*)	**308.** (*c*)	**309.** (*a*)	**310.** (*c*)	**311.** (*b*)	**312.** (*a*)

*Indicates that explanatory note is given at the end.

313. (*a*)	**314.** (*c*)	**315.** (*c*)	**316.** (*a*)	**317.** (*d*)	**318.** (*c*)	**319.** (*d*)	**320.** (*c*)
321. (*c*)	**322.** (*d*)	**323.** (*b*)	**324.** (*c*)	**325.** (*a*)	**326.** (*c*)	**327.** (*d*)	**328.** (*a*)
329. (*e*)	**330.** (*a*)	**331.** (*c*)	**332.** (*a*)	**333.** (*a*)	**334.** (*c*)	**335.** (*c*)	**336.** (*a*)
337. (*d*)	**338.** (*a*)	**339.** (*d*)	**340.** (*b*)	**341.** (*c*)	**342.** (*d*)	**343.** (*a*)	**344.** (*b*)
345. (*d*)	**346.** (*d*)	**347.** (*d*)	**348.** (*d*)	**349.** (*c*)	**350.** (*d*)	**351.** (*a*)	**352.** (*d*)
353. (*b*)	**354.** (*a*)	**355.** (*e*)	**356.** (*e*)	**357.** (*a*)	**358.** (*b*)	**359.** (*d*)	**360.** (*a*)
361. (*a*)	**362.** (*d*)	**363.** (*c*)	**364.** (*c*)	**365.** (*c*)	**366.** (*c*)	**367.** (*a*)	**368.** (*a*)
369. (*a*)	**370.** (*b*)	**371.** (*a*)	**372.** (*b*)	**373.** (*a*)	**374.** (*c*)	**375.** (*c*)	**376.** (*c*)
377. (*c*)	**378.** (*c*)	**379.** (*c*)	**380.** (*e*)	**381.** (*b*)	**382.** (*d*)	**383.** (*c*)	**384.** (*d*)
385. (*b*)	**386.** (*a*)	**387.** (*e*)	**388.** (*e*)	**389.** (*c*)	**390.** (*c*)	**391.** (*b*)	**392.** (*a*)
393. (*a*)	**394.** (*d*)	**395.** (*c*)	**396.** (*e*)	**397.** (*d*)	**398.** (*b*)	**399.** (*e*)	**400.** (*e*)
401. (*d*)	**402.** (*a*)	**403.** (*d*)	**404.** (*b*)	**405.** (*c*)	**406.** (*d*)	**407.** (*a*)	**408.** (*c*)
409. (*b*)	**410.** (*a*)	**411.** (*d*)	**412.** (*e*)	**413.** (*a*)	**414.** (*b*)	**415.** (*a*)	**416.** (*a*)
417. (*a*)	**418.** (*b*)	**419.** (*b*)	**420.** (*a*)	**421.** (*c*)	**422.** (*b*)	**423.** (*a*)	**424.** (*d*)
425. (*a*)	**426.** (*c*)	**427.** (*a*)	**428.** (*b*)	**429.** (*c*)	**430.** (*b*)	**431.** (*b*)	**432.** (*e*)
433. (*c*)	**434.** (*b*)	**435.** (*c*)	**436.** (*d*)	**437.** (*e*)	**438.** (*a*)	**439.** (*b*)	**440.** (*c*)
441. (*d*)	**442.** (*d*)	**443.** (*d*)	**444.** (*c*)	**445.** (*b*)	**446.** (*d*)	**447.** (*e*)	**448.** (*a*)*
449. (*c*)	**450.** (*e*)	**451.** (*c*)	**452.** (*d*)	**453.** (*d*)	**454.** (*d*)	**455.** (*b*)	**456.** (*a*)
457. (*b*)	**458.** (*b*)	**459.** (*c*)	**460.** (*b*)	**461.** (*b*)	**462.** (*d*)	**463.** (*c*)	**464.** (*b*)
465. (*d*)*	**466.** (*d*)*	**467.** (*d*)*	**468.** (*d*)*	**469.** (*d*)*	**470.** (*a*)	**471.** (*b*)	**472.** (*d*)
473. (*a*)	**474.** (*d*)*	**475.** (*c*)*	**476.** (*c*)	**477.** (*a*)	**478.** (*b*)*	**479.** (*a*)*	**480.** (*b*)
481. (*c*)	**482.** (*a*)	**483.** (*b*)	**484.** (*a*)*	**485.** (*d*)	**486.** (*b*)	**487.** (*c*)	**488.** (*d*)
489. (*c*)	**490.** (*c*)	**491.** (*b*)	**492.** (*b*)	**493.** (*b*)*	**494.** (*a*)*	**495.** (*c*)	**496.** (*c*)*
497. (*d*)*	**498.** (*b*)*	**499.** (*d*)*	**500.** (*c*)*	**501.** (*a*)*	**502.** (*c*)*	**503.** (*b*)*	**504.** (*a*)*
505. (*a*)*	**506.** (*d*)*	**507.** (*c*)					

EXPLANATORY NOTES

104. As density of atmosphere varies with altitude, decrease is not linear.

113. It is an ordinary manometer containing only the fluid in conduit and thus very sensitive.

143. Weight in air = Weight in water + ρ × *V*

or, $3 = 2.5 + 1000 \times V$

or, $V = \dfrac{0.5}{1000}$

$\therefore \quad \text{S.G.} = \dfrac{\text{Wt. in air}}{V \times \rho} = \dfrac{3 \times 1000}{0.5 \times 1000} = 6.$

163. Froude No. of prototype = Froude No. of model

or $\dfrac{V}{\sqrt{gL}} = \dfrac{V'}{\sqrt{g'L'}} \quad \dfrac{V}{\sqrt{L}} = \dfrac{V'}{\sqrt{L'}}$ (as $g = g'$)

$\therefore \quad \dfrac{10}{\sqrt{100}} = \dfrac{V'}{\sqrt{100/25}}$

or $\dfrac{10}{10} = \dfrac{V'}{2}$ and V′ = 2 m/sec.

165. Reynold no. of prototype and model has to be same.

$\therefore \quad \dfrac{5 \times l}{\mu} = \dfrac{25 \times l'}{\mu'}$ ($\mu = \mu'$)

$\therefore \quad \dfrac{l}{l'} = \dfrac{5}{25} = 1 : 5.$

215. If *V* is volume of metal, and *x* the fraction under mercury, then

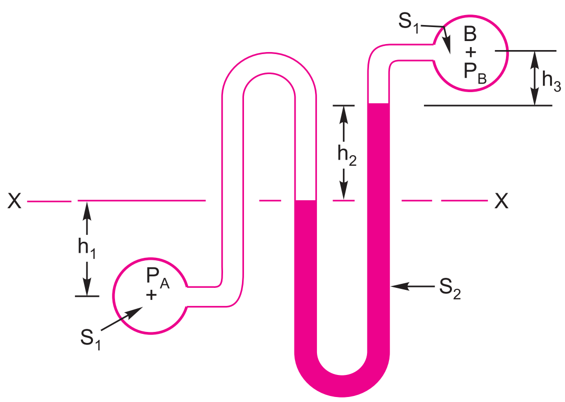
$$\frac{xV}{V} = \frac{7}{13.6} \quad \text{and} \quad x = 0.515.$$

216. If *V* is total volume of wood, and *S* its sp. gravity ; and if *V* is volume under water, then

$$\frac{V'}{V} = \frac{S}{1} \quad \text{or} \quad S = \frac{60}{100} = 0.6.$$

448. Head loss in hydraulic jump $\dfrac{(y_1 - y_2)^2}{4y_1y_2}$

465. Considering the datum at *XX* in Fig. below, the net pressure on left side is $p_A - h_1S_1$ (the pressure due to inverted portion being equal)



*Indicates that explanatory note is given at the end.

and net pressure on right side = $p_B + h_3S_1 + h_2S_2$

$\therefore \quad p_A - p_B = h_1S_1 + h_2S_2 + h_3S_1$

466. Fig. in Q. 466 is a plot of log (friction factor 'f') and log (Reynolds number 'Re'). It would be seen that for smooth turbulent flow, f varies inversely as Re.

But in case of rough pipes, behaviour changes depending on value of relative smoothness r/k (radius/average diameter of sand particles).

Thus friction factor f for rough turbuluent flow in a pipe depends upon pipe condition and pipe diameter.

Friction factor for laminar flow $f = \frac{64}{Re}$, *i.e.*, it is independent of the relative roughness of pipe. However in the turbulent flow, the friction factor, as observed from several experiments, is a function of the relative roughnesss *i.e.*, the pipe condition and pipe diameter. Thus (d) is the correct choice.

467. In this case, the number of physical quantities given are $n = 8$. Number of fundamental dimensions $m = 3$.

According to Buckingham π theorem, number of independent non-dimensional groups = $n - m$ = $8 - 3 = 5$.

468. Euler number is concerned with pressure force and this choice is available for A in code (d) only. If one is confident, then there is no need to look for items B, C and D. However a cross check will show that Froude number is concerned with gravity force, Mach number with elastic force, and Weber number with surface tension.

469. Head lost due to friction is 6 m. Power transmitted is maximum when friction head is 1/3 of the supply head.

$\therefore$ Supply head should be 18 m.

474. Velocity head is $\frac{V^2}{2g} = hS_2 - hS_1$,

and $\qquad V = \sqrt{2gh(S_2 - S_1)}$.

475. The expression $p + \rho gz + \frac{\rho V^2}{2}$ has units of $\frac{N}{m^2}$

or $\qquad \frac{Nm}{m^3}\left(\frac{\text{energy}}{\text{volume}}\right)$.

478. Thickness of boundary layer at 4 mm from leading edge = $2 \times (4/2)^{1/2} = 2 \times 2^{1/2}$ mm.

479. Force ratio = $\frac{\rho_m}{\rho_p} \times \frac{L_m^2}{L_p^2} \times \frac{V_m^2}{V_p^2}$;

$$\frac{F_m}{F_p} = 1 \times \left(\frac{1}{10}\right)^2 \times \left(\frac{5}{10}\right)^2 \quad \text{or} \quad \frac{50}{F_p} = \frac{1}{100} \times \frac{1}{4}$$

or $\qquad F_p = 50 \times 400 = 20000$ N.

484. Hydrostatic force at bottom = $\rho g A\bar{z} = \rho g(2x \times 1x) \times \frac{2x}{2}$ (length = $2x$; breadth = $1x$; height = $2x$) = $2\rho g x^3$

Hydrostatic force at larger vertical surface = $\rho g (2x \times 2x) \times 2x/2 = 4\rho g x^3$

$\therefore$ Ratio of above forces = 1/2.

493. Force at bottom = $\rho g A \times 2h$

Force at side of tank = $\rho g A \times \frac{2h}{2}$

$\therefore$ Ratio of forces at bottom to side = 2.

494. When half the liquid is spilled, there will be no liquid at centre because in such a case the height of paraboloid formed is half above and half below the liquid level at rest. Thus pressure at the centre of bottom will be zero.

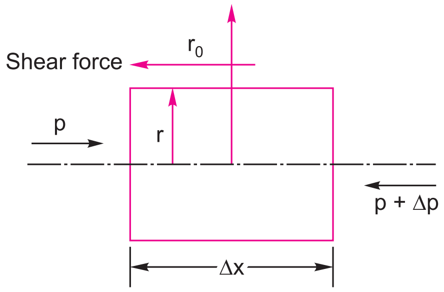
496. Whatever is the weight of iron piece buoyancy force to same extent acts upward and thus spring balance on which water bucket is hanging will show no change in reading.

497. Pressure inside rain drop = $\frac{4T}{d} = \frac{4 \times 0.073}{0.001}$

$= 292 \text{ N/m}^2$

498. For Laminar flow in pipe,

$$\frac{\Delta V}{\Delta r} = \frac{1}{\mu}\,\frac{\Delta p}{\Delta x}\cdot\frac{r}{2}$$



or $\qquad \Delta V = \frac{1}{2}\frac{1}{\mu}\cdot\frac{\Delta p}{\Delta x}\, r\,\Delta r$

$$\int_V^0 \Delta V = \frac{1}{2}\frac{1}{\mu}\cdot\frac{\Delta p}{\Delta x}\int_0^{r_0} r\,\Delta r$$

(V = velocity in center and = 0 at outer layer)

or $\qquad -V = \frac{\Delta p}{\Delta r}\cdot\frac{1}{4\mu}(r_0^2 - r^2) \qquad$ ...(1)

Also, average velocity $\quad \bar{V} = \frac{Q}{A} = \frac{\frac{\Delta p \pi r_0^4}{\Delta x \cdot 8\mu}}{\pi r_0^2}$

$= -\frac{\Delta p}{\Delta r}\,\frac{r_0^2}{8\mu} \qquad$ ...(2)

Comparing (1) and (2),

$$\frac{r_0^2}{2} = r_0^2 - r^2$$

or $\qquad r^2 = \frac{r_0^2}{2}$ and $r = \frac{r_0}{\sqrt{2}}$

499. For square pipe, $\quad A = L^2, P = 4L$

$$D_{eq} = \frac{4A}{P} = \frac{4L^2}{4L} = L$$

For triangular pipe, $A = \frac{\sqrt{3}}{4}L^2$, $P = 3L$

$$D_{eq} = \frac{4A}{P} = \frac{4\sqrt{3}L^2}{4(3L)} = \frac{L}{\sqrt{3}}$$

For rectangular pipe,

$$A = \frac{L^2}{2}, P = \frac{L}{2} + \frac{L}{2} + L + L = 3L$$

$$D_{eq} = \frac{4A}{P} = \frac{4\frac{L^2}{2}}{3L} = \frac{2}{3}L.$$

500. The buoyant effect in water is the difference between the weight in air and in water, *i.e.,* 100 – 60 = 40 kg. This buoyant effect equals the weight of water displaced or the volume of displaced water multiplied by the specific weight of water.

$\therefore \quad \rho_w V = 40$

or $\quad V = \frac{40}{1000}\ \text{m}^3$

Specific weight of stone

$$= \frac{\text{Weight in air}}{V} = \frac{100}{40} \times 1000$$

$$= 2500\ \text{kg/m}^3.$$

501. For similarity, Reynolds number in propotype and model must be equal

i.e. $\quad \frac{\rho_p V_p D_p}{\mu_p} = \frac{\rho_m V_m D_m}{\mu_m}$

or $\quad \frac{V_p}{V_m} = \left(\frac{\rho_m}{\rho_p}\right)\left(\frac{D_m}{D_p}\right)\left(\frac{\mu_p}{\mu_m}\right) = \frac{1000}{1} \times \frac{1}{10} \times \frac{1}{100} = 1$

$$\frac{P_p}{P_n} = \frac{\rho_p}{\rho_m} \times \left(\frac{V_p}{V_m}\right)^2 = \frac{1}{1000} \times \left(\frac{1}{1}\right)^2$$

or $\quad P_p = 1 \times \frac{1}{1000} \times \left(\frac{1}{1}\right)^2 = 0.001\ \text{kg/cm}^2.$

502. In this case Froude number must be same for model and prototype.

i.e., $\quad \frac{V^2}{Lg} = \text{constant}$

or $\quad \frac{V_m^2}{L_m} = \frac{V_p^2}{L_p}$ or $\frac{V_m^2}{V_p^2} = \frac{L_m}{L_p} = \frac{3}{300} = \frac{1}{100}$

$\therefore \quad V_m = \frac{1}{10} V_p = \frac{100}{10} = 10$ km/hr.

Force requirement is given by

$$\left(\frac{F}{\rho L^2 V^2}\right)_m = \left(\frac{F}{\rho L^2 V^2}\right)_p$$

or $\quad \left(\frac{F_m}{F_p}\right) = \left(\frac{\rho_m}{\rho_p}\right)\left(\frac{L_m}{L_p}\right)^2\left(\frac{V_m}{V_p}\right)^2$

$$= \frac{1}{1} \times \left(\frac{10}{1000}\right)^2 \times \left(\frac{1}{10}\right)^2 = 10^{-6}.$$

503. Sphere is an ideal pressure vessel for economy. Where requirements exceed practicable for single sphere, multiple intersecting sphere are used which offer most economical design of vessels for extremely high pressures. Thus section (*B*) is ideally suited for the given application.

504. It is important to have some relative idea of absolute viscosity of some substances. With rise in temperature, viscosity of gases increases and that of liquid decreases. Moreover viscosity of gases is much less compared to liquids. Thus curve *D* is for air. Among glycerine, crude oil and water, water is least viscous and thus curve *C* is for water. Glycerine is most viscous and therefore curve *A* is applicable for it.

505. $A \times V = Q$

or $\quad V = \frac{Q}{A} = \frac{20}{2 \times 4} = 2.5$ m/sec.

For checking, whether flow is critical/subcritical/supercritical, determine the value of $\frac{V^2}{gy}$ (y = depth)

$$= \frac{2.5^2}{9.81 \times 2} < 1$$

The flow is therefore subcritical.

506. Flow over *V*-notch $\propto h^{5/2}$

$\therefore$ For double depth

Flow $\propto (2h)^{5/2}$

$\propto \sqrt{32}\ h^{5/2}$

$\simeq \propto 5.6.$

PROBLEMS

Provide single suitable word(s) for following statements :

1. The branch of applied mechanics dealing with the behaviour of fluids at rest and in motion.
2. When in equilibrium, fluids can't sustain .... forces.
3. Ratio of the mass of a body to the mass of an equal volume of a substance taken as a standard.
4. The property which determines the amount of its resistance to a shearing force.
5. Kinematic coefficient of viscosity is the ratio of absolute viscosity and ....
6. Viscosities of liquids .... affected by pressure changes.
7. Kinematic viscosity of gases varies .... as the pressure.
8. Surface molecules have .... energy than interior molecules in a liquid.
9. The work to be done to bring enough molecules from inside the liquid to the surface to form one new unit area of that surface.

10. The liquids rise in tubes when adhesion of liquid to walls is .... cohesion of the liquid.

11. The ratio of the change in unit pressure to the corresponding volume change per unit of volume.

12. A fluid in which the shear stress is proportional to the velocity gradient or shearing strain.

13. A fluid for which the resistance to shearing deformation is zero.

14. Longitudinal stress in thin-walled cylinders closed at the ends is equal to .... the hoop tension.

15. The line of action of force exerted by a liquid on a plane area passes through the ....

16. The position of the centre of pressure is always .... the centre of gravity of the area.

17. The force acting on any weight floating or immersed in a liquid, then force being equal to the weight of the liquid displaced.

18. The point through which the buoyant force acts is called the centre of buoyancy and it is located at the .... of the displaced liquid.

19. For stability of a submerged body, the centre of gravity of body must lie directly .... the centre of buoyance of the displaced liquid.

20. If the ratio of all corresponding dimensions of model and prototype are equal.

21. If the paths of homologous moving particles are geometrically similar and if the ratios of the velocities of homologous particles are equal.

22. If the ratios of all homologous forces in geometrically and kinematically similar models and prototypes are the same.

23. Inertial pressure force ratio.

24. Inertia-viscous force ratio.

25. Inertia-gravity force ratio.

26. Inertia-elasticity force ratio.

27. Square root of Cauchy number.

28. Inertia-surface tension ratio.

29. An incompressible fluid flow in which the direction and magnitude of the velocity at all points are identical.

30. A fluid flow in which the fluid particles move in planes or parallel planes and the streamline patterns are identical in each plane.

31. An ideal flow which can be represented by a flow net (*i.e.,* no shear stresses and no torques exist).

32. A flow, in which, at any point, the velocity of successive fluid particles is the same at successive periods of time.

33. A flow in which the magnitude and direction of the velocity do not change from point to point in the fluid.

34. Imaginary curves drawn through a fluid to indicate the direction of motion in various sections of the flow of the fluid system.

35. Equation of .... results from the principle of conservation of mass.

36. Energy at any section, plus energy added, minus the energy lost and extracted, is equal to energy at the end.

37. The hydraulic grade line lies below the energy line by an amount equal to the .... at that section.

38. A flow in which the fluid particles move along straight, parallel paths in layers.

39. The .... velocity of practical interest is the velocity below which all turbulence is damped out by the viscosity of the fluid.

40. The upper limit of laminar flow of practical interest is represented by a Reynold number of about ....

41. The ratio of the cross-sectional area to the wetted perimeter for non-circular cross-sections.

42. A flow in which the particles of the fluid move in a haphazard fashion in all directions.

43. Velocity distribution at a cross-section of variation for laminar flow.

44. In laminar flow the maximum velocity at the centre of pipe is .... the average velocity.

45. Used to measure the velocity head of flowing fluid.

46. The ratio of area of jet (pitot tube) at vena-contracta and the area of orifice.

47. The product of coefficient of velocity and coefficient of contraction.

48. The ratio of loss of kinetic energy in the orifice and the actual kinetic energy.

49. If V_1 and V_2 be velocity at inlet and outlet, then loss of head due to sudden enlargement is proportional to ....

50. Loss of head due to sudden contraction is proportional to ....

51. Coefficient of discharge is unity in case of .... mouth piece.

52. Coefficient of contraction for an internal mouthpiece is ....

53. A sharp edged obstruction over which flow of a fluid takes place.

54. The sheet of water which flows over the notch or weir.

55. Flow over rectangular notch is proportional to ....

56. Flow over triangular notch is proportional to ....

57. A trapezoidal notch having side slopes of one horizontal to four vertical.

58. The ratio of head lost due to friction and total length of pipe.

59. A pipe of uniform diameter which replaces the compound pipe consisting of several pipes of different diameters and lengths.

60. Transmission of power through pipe is maximum when loss of head due to friction in pipe is .... of the total head supplied at the entrance to the pipe.

61. According to Froude, the frictional resistance in pipe is proportional to ....

62. Flow in a pipe will be turbulent when Reynold's number is greater than ....

63. A flow measuring device in which indication is essentially linear with flow rate.

64. A flow in which the velocity, *i.e.* depth of flow varies from one section to another.

65. In case of rectangular open channel, the width of channel should be .... the depth for maximum discharge.

66. For maximum efficiency, the trapezoidal section of open channel should form a ....

67. For maximum discharge in circular shape open channel, depth should be equal to .... times diameter of pipe.

68. The depth of flow for the given discharge in a channel, corresponding to minimum specific energy.

ANSWERS

1. fluid mechanics	**2.** shear	**3.** relative density	**4.** viscosity
5. mass density	**6.** are not	**7.** inversely	**8.** more
9. surface tension	**10.** greater than	**11.** bulk modulus of elasticity	
12. Newtonian fluid	**13.** ideal fluid	**14.** half	**15.** centre of pressure
16. below	**17.** buoyant force	**18.** centre of gravity	**19.** below
20. geometric similitude	**21.** Kinematic similitude	**22.** dynamic similitude	**23.** Euler number
24. Reynolds number	**25.** Froude number	**26.** Cauchy number	**27.** Mach number
28. Weber number	**29.** true one dimensional flow		**30.** two-dimensional flow
31. irrotational flow	**32.** steady flow	**33.** uniform flow	**34.** streamlines
35. continuity	**36.** Bernoulli's theorem	**37.** velocity head	**38.** laminar flow
39. critical	**40.** 2000	**41.** hydraulic radius	**42.** turbulent flow
43. parabolic law	**44.** twice	**45.** pitot tube	**46.** coefficient of contraction
47. coefficient of discharge		**48.** coefficient of resistance	**49.** $[(V_1 - V_2)^2]$
50. $(V_2)^2$	**51.** convergent divergent	**52.** 0.5	**53.** notch
54. nappe or vein	**55.** $(H^{3/2})$	**56.** $(H^{5/2})$	**57.** Cippoletti notch
58. hydraulic gradient	**59.** equivalent pipe	**60.** one-third	**61.** (V^2)
62. 4000	**63.** rotameter	**64.** non-uniform flow	**65.** twice
66. half hexagon	**67.** 0.95	**68.** critical depth	