VISCOSITY

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- Fluids flow from one place to other because of pressure difference.
- When a liquid flows on a surface, it can be imagined to do so in different layers. The upper layer tries to drag forward the lower layer increasing the velocity of lower layer, where as the lower layer tries to drag backward the upper layer decreasing the upper layer's velocity.
- Viscous force is the force of friction acting between two layers of a liquid, opposing the relative motion of one over the other.
- The velocity of the layers goes on decreasing as the depth increases and finally the deepest layer in contact with the horizontal surface is at rest.
- The ratio of the difference in velocities and the distance between two points in the liquid, perpendicular to the plane of the liquid is called velocity gradient, it is denoted by $\frac{dv}{dx}$

$$\frac{dv}{dx} = \frac{V_1 - V_2}{L}$$

- Viscosity of liquid is due to cohesive forces between the liquid molecules where as viscosity of gases is due to collisions between the gas molecules.
- Waves in sea water subside due to viscosity.
- Rain drops fall to the ground with terminal velocity due to viscosity.
- When water in a beaker is stirred with a rod at its centre the layers of water move with different speeds. When stirring is stopped, the relative velocity between its layers gradually decreases and finally water comes to rest. This is due to viscosity.
- The viscosity and compressibility of an ideal fluid is zero. (Non viscous, incompressible fluid is ideal fluid)

Note : No fluid behaves like an ideal fluid.

- It is only due to viscosity, a liquid flow becomes orderly.

VISCOUS FORCE:
(NEWTON'S FORMULA)

- The viscous force acting between two adjacent layers of a liquid is directly proportional to the surface area of the layers in contact and the velocity gradient.
  i.e. $F \propto A$ and

$$F \propto \frac{dv}{dx}$$

$$\Rightarrow F \propto A\frac{dv}{dx}$$

$$F = -\eta A\frac{dv}{dx}$$

The viscous force acts tangential to the liquid and in opposite direction to the direction of flow of liquid. Hence negative sign is used. η is coefficient of viscosity.

- 'η' may be defined as the tangential force per unit area required to maintain unit velocity gradient. (or) It is the ratio between tangential stress and velocity gradient. It is also called coefficient of dynamic viscosity.
- Dimensional formula of $\eta = M^1L^{-1}T^{-1}$
- The S.I. unit of coefficient of viscosity is $\frac{Ns}{m^2}$ (or) pascal second. (Pa.s)
- The C.G.S. unit of η is $\frac{dyne}{cm^2}s$ (or) POISE.
- 1 pa.s = 10 poise.

Note : The value of η changes from liquid to liquid and for ideal liquid η=0

COEFFICIENT OF KINEMATIC VISCOSITY:

- The ratio between the coefficient of viscosity and density of the liquid is called Kinematic viscosity.

  Kinematic viscosity $= \frac{\eta}{\rho}$

- Its S.I. unit is m^2s^{-1}
- Its practical unit is stoke. 1 stoke = $10^{-4}m^2s^{-1}$.
- Its dimensional formula is $\left[L^2T^{-1}\right]$, same as that of areal velocity.

EFFECT OF TEMPERATURE:

- In the case of liquids, coefficient of viscosity decreases with increase of temperature as the cohesive forces decrease with increase of temperature.
- In the case of gases, coefficient of viscosity increases with increase of temperature because the change in momentum of molecules increases with increase of temperature.

EFFECT OF PRESSURE:

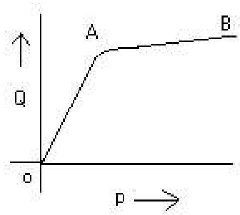
- For liquids the value of η increases with increase of pressure.
- For gases, value of η increases with increase of pressure at low pressure. But at high pressure, η is independent of pressure.

POISEUILLE'S EQUATION:

- When a liquid is flowing through a tube, the velocity of the flow of a liquid at a distance x from the axis of tube is given by $v = \frac{P}{4\eta l}\cdot\left[r^2 - x^2\right]$

  where P is pressure difference across the ends of the tube, r is the radius of the tube, l is the length of the tube.
- The velocity distribution curve of the advancing liquid in a tube is a parabola. The velocity of the liquid at the walls of the tube is zero and increases to maximum at the centre.
- The volume of liquid flowing through the capillary tube per second is given by the poiseuille's equation.

  $Q = \frac{\pi Pr^4}{8\eta l}$ where P = hdg.
- The above relation holds good when
  1. The flow of liquid is stream line.
  2. The velocity of flow is small and the tube is narrow.
  3. The pressure is constant at every cross section i.e., there is no radial flow.
  4. The liquid in contact with the walls of the tube is stationary.
- If the flow is stream line, velocity of liquid (v) is proportional to pressure difference (p)



- In turbulent motion $v \propto \sqrt{p}$ approximately.
- In turbulent motion, all liquids require same pressure difference to flow through a tube with same velocity.
- Poiseuille's method to determine η of a liquid is suitable only for liquids of low value of η.
- From Poiseuille's equation

  $$Q = \frac{\pi Pr^4}{8\eta l} \Rightarrow \frac{P}{Q} = \frac{8\eta l}{\pi r^4} = R$$

  $\frac{P}{Q}$ is called fluid resistance (R)

  Fluid resistance in hydrodynamics is analogous to electric resistance in current electricity.
- **CAPILLARIES IN SERIES:**

  When two capillary tubes are connected in Series, total pressure $P = P_1 + P_2 + ...$
  - Fluid resistance R= $R_1 + R_2 + ...$ (increases)

    Rate of flow i.e., volume of the liquid flowing per second is same. i.e., $V_1 = V_2 = V_3$ ....
- **Capillaries in parallel :**
  - When capillary tubes are connected in parallel, the total pressure remains constant. i.e., $P_1 = P_2 = P_3$ .....

    fluid resistance $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

    volume of the fluid flowing per second i.e, rate of flow $V = V_1 + V_2 + V_3 + ...$

STOKE'S FORMULA :

- The viscous force acting on a spherical body of radius 'r' moving with velocity v in a liquid of coefficient of viscosity 'η' is given by

  $$F = 6\pi\eta rv$$
- When a spherical body is dropped in a liquid, the net force on the body is zero at a stage and it travels with uniform velocity and this is called terminal velocity (V_T).

  $$V_T = \frac{2}{9}\cdot\frac{gr^2[d-\rho]}{\eta}$$

  where d = density of the body,
  r = radius of the body
  g = acceleration due to gravity
  ρ = density of the liquid
  V_T depends upon the densities of the body and liquid.
- If the density of the liquid is greater than the density of the body $(\rho > d)$, the body rises up to the top with terminal velocity.

  Ex: Air bubble rising from the bottom to top of a lake may acquire terminal velocity, if the depth is sufficiently large.

FLUID DYNAMICS:

It is the study of behaviour of liquids in motion.

THE RATE OF FLOW OF A LIQUID:

- The rate of flow of a liquid means the volume of a liquid that flows across any cross section in unit time and is given by

  $$Q = \frac{Volume}{time} \Rightarrow \left[m^3 s^{-1}\right]$$

  Mass of the liquid that flows per unit time

  $$= \frac{Volume}{time} \times density = \frac{A.l.\rho}{t} = AV\rho$$

  Where A is the area of cross section of the tube,V is the velocity of the liquid and ρ is the density of the liquid.

TYPES OF FLOW OF LIQUID:

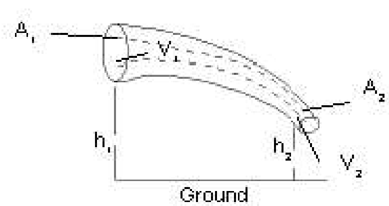
- There are two types of liquid flow.
  1. Stream line flow 2. Turbulent flow.
- Stream line flow is also called Laminar flow or Steady flow. If the motion of the parallel layers is in an orderly fashion and maintains uniform velocity gradient, then the motion of flow is called laminar flow.
- The velocity at a point in a fluid remains constant both in magnitude and direction at any time.
- A stream line may be a straight line or a curve.
- The tangent drawn at any point of curved stream line gives the direction of velocity of the particle at that point.
- Stream lines never intersect each other.
- Rate of flow of liquid depends upon Viscosity.
- An imaginary tube consisting of a number of stream lines is called a stream line tube.
- The mass of the liquid entering a tube at one end is equal to that of the liquid leaving it from the other end if there is no radial flow of liquid through the walls of the tube.
- **EQUATION OF CONTINUITY :** When an ideal fluid (i.e., an incompressible and non-viscous fluid) flows through a tube of non-uniform cross section, the product of area of cross section and velocity of flow is constant.
  $A \times v$ = Constant $\Rightarrow A_1 v_1 = A_2 v_2$
  (Θ ρ is Constant)
  Equation of continuity represents the law of Conservation of mass in case of moving fluids.
  The velocity of flow increases, if area of cross section decreases and vice versa.
  $v \alpha \frac{1}{A}$ (or) $\frac{1}{r^2} \propto v$
- If the flow of liquid is irregular or zig-zag, then it is called turbulent flow.. Eddies and whirl pools are formed in turbulent flow.
- In turbulent flow, the velocity of liquid at a point is not constant.
- Critical Velocity is the velocity beyond which stream line flow is gradually changed to turbulent flow.
- Critical Velocity $V_c = \frac{K\eta}{r\rho}$
  [Where η is the coefficient of viscosity, K is constant of proportionality called Reynold number r is radius of the tube through which liquid flows. ρ is density of the liquid.]
- Depending upon the radius of the pipe, the density and coefficient of viscosity of the liquid, Reynold number lies between 2000 and 3000.
- When the value of K > 3000 then the liquid flow becomes turbulent.
- When the value of K is less, viscous forces are predominant and when its value is large, inertial forces predominate.

PRESSURE ENERGY:

- The energy possessed by a fluid by virtue of its pressure is called the pressure energy.
- Pressure energy is equal to the work done in keeping an elementary mass of a fluid at a point against the pressure existing at that point.
- Pressure energy=PressurexVolume = P x A x x.
  [Where P = pressure, A = Area of cross section, x = distance through which liquid is moved]
- Pressure energy per unit volume = $\frac{P \times A \times x}{A \times x} = P$
- Pressure energy per unit mass (or) Static pressure
  $$= \frac{P \times A \times x}{\rho \times A \times x} = \frac{P}{\rho} = \frac{\text{Pr}essure}{density}$$
- Pressure energy has same units and dimensions as that of energy.

BERNOULLI'S THEOREM:

- A fluid in motion possesses three types of energy namely kinetic energy, potential energy and pressure energy.
  (i) K.E = $\frac{1}{2}mv^2$; (ii) $PE = mgh$
  (iii) Pressure energy = $P \times V$
- Bernoulli's Theorem states that the sum of the pressure energy, kinetic energy and potential energy at any point in steady flow calculated per unit mass or per unit volume is constant.
  $\frac{P}{\rho} + \frac{1}{2}v^2 + gh = Cons\tan t.$ (per unit mass)
  (or) $\frac{P}{\rho g} + \frac{v^2}{2g} + h$ = Constant
  Here $\frac{P}{\rho g}$ is called pressure head, $\frac{v^2}{2g}$ is called Velocity head and h is called gravitational head.



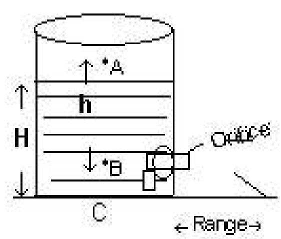
Bernoulli's Theorm can also be stated as follows: "In a stream line flow of liquid, the sum of gravitational head, pressure head and velocity head at any point in the path of the flow is constant"

- When the flow is horizontal, h is same and hence sum of pressure head and velocity head is constant.
- $P+\frac{1}{2}\rho v^2+\rho gh$ = constant (per unit volume)

  Here $\frac{1}{2}\rho v^2$ is called dynamic pressure.

  ($P+\rho gh$) is called static pressure
- Bernoulli's theorem represents Law of conservation of energy
- In the case of horizontal pipe in which liquid flows,

  $P_1+\frac{1}{2}\rho v_1^2=P_2+\frac{1}{2}\rho v_2^2$



$\Rightarrow P_1-P_2=\frac{1}{2}\rho\left(v_2^2-v_1^2\right)$

Where P_1 and P_2 are pressures at two points, v_1, v_2 are velocities at two points and ρ is the density of the liquid.

- For horizontal flow of liquid, maximum pressure corresponds to minimum velocity and vice versa $\left(P\alpha\frac{1}{V}\right)$

TORRICELLI'S THEOREM:

- The velocity of efflux of a liquid through an orifice is equal to that of the velocity acquired by a freely falling body from a height which is equal to that of the liquid level from the orifice. $\boxed{v=\sqrt{2gh}}$
- Time taken by the efflux liquid to reach the ground is given by $t=\sqrt{\frac{2(H-h)}{g}}$
- Horizontal range of the liquid is given by R = $V\times t$

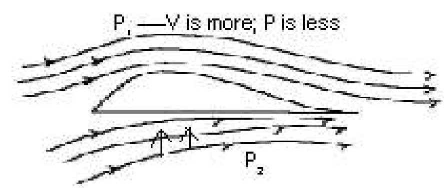
  $R=\sqrt{2gh.\frac{2(H-h)}{g}}=2\sqrt{h(H-h)}$
- Horizontal range is <u>maximum</u> when the orifice is at the middle of liquid level and bottom.

  i.e., if $h=\frac{H}{2}$ then $R_{Max}=H\Rightarrow 2h$
- A cylindrical vessel of area of cross section 'A' has a hole of area of cross section 'a' at its bottom. Time taken for the water level to decrease from h_1 to h_2 as water flows out from the hole is

  $t=\frac{A}{a}.\sqrt{\frac{2}{g}}\left[\sqrt{h_1}-\sqrt{h_2}\right]$
- The volume of the liquid coming out of the orifice per second = $V=A.\sqrt{2gh}=\pi r^2.\sqrt{2gh}$ (since $V=Av$)

APPLICATIONS OF BERNOULLI'S THEOREM:

- **<u>Dynamic lift</u>** : The upward lift experienced by a body in motion when immersed in a fluid is called dynamic lift.
- The dynamic lift experienced by a body when it is in motion in air is called aerodynamic lift.
- Aeroplanes get the dynamic lift because of the shape of their wings.



$P_{upper}<P_{lower}$

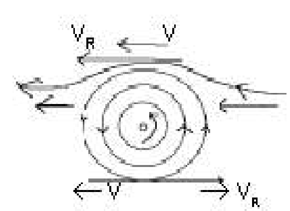
The upper surface of the wing is more curved than the lower surface. Air flows with greater speed above the wing and so pressure above the wing will be less than that at the bottom.

This difference in pressures produces the aerodynamic lift and allows aeroplane to fly.

Dynamic lift = $(P_2-P_1)A$

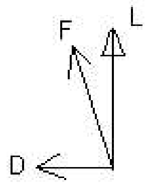
$=\frac{1}{2}\rho.\left(V_1^2-V_2^2\right)\times A$

- **<u>Spinning ball</u>** :



The plane of motion of a spinning ball gets changed due to an effect called <u>magnus effect</u>. On the top of the ball, the linear velocity (V) and

Rotational Velocity V_R act in the same direction.
Hence resultant velocity on the top is $V+V_R$.
At the bottom of the ball resultant velocity is $V-V_R$
Therefore, pressure on the top of the ball will be less than that at the bottom. There is a net force acting on the ball in upward direction. This force F is not perpendicular to the initial direction of the stream lines but slightly inclined to the normal.



The vertical component 'L' of this force is called lift and horizontal component D of the force is called drag. It is due to these reasons, the path of the spinning ball is curved.
Hence it is difficult to face a spinning ball rather than a straight ball in cricket game.

- When wind blows over a house with high speed, pressure on the roof will be less than that of inside the house, and so the roof is lifted up and blown away by the wind.

6. When air is blown between two balls suspended, velocity of air between them will be more, pressure decreases and so they attract each other.

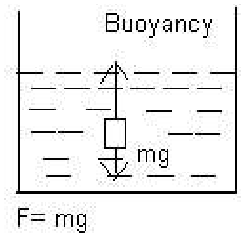
- Pieces of paper, straw, light bodies etc., are pulled towards a fast moving train or vehicle because of pressure difference developed due to speed difference.
- Atomiser, paintgun and Bunsen burner, work on basis of Bernoulli's Theorem.

Buoyancy: When a body is partly or wholly immersed in a fluid the fluid exerts force on the body due to hydrostatic pressure normal to the surface and equal to the pressure at that point multiplied by area.

Laws of floatation:

W and W_1 are the weight of a body and the buoyant force on it.
i) If $W > W_1$ body sinks, ii) $W = W_1$ body is just submerged (body floats with its volume completely under the liquid), iii) $W < W_1$ body floats (a part of the body lies outside the liquid)
iv) A body of volume V and density D is floating with a volume u inside the fluid of density d. then VD = ud.
v) A body of mass M is floating in a liquid. To make it to just sink, the mass m to be placed on it is given by (m + M) = Vd which V = volume of the body but d = density of liquid.

Archimdie's Principle: When a body is immersed partly or wholly in a fluid it loses some weight, which is equal to the weight of the liquid displaced by the body
Buoyancy : Weight of fluid displaced =
$\Delta F_B = mg = V\rho g$



M = mass of liquid displaced
V = Volume of body immersed or volume of fluid displaced
ρ = density of fluid
g = acceleration due to gravity
Apparent loss of weight of the body in the fluid
$= [Mg-(Mg- V\rho g)]= V\rho g$
= weight of fluid displaced
Where M = Mass of the body immersed
Upthrust or buoyancy is independent of mass, size, density shape etc of the body. It depends only on the volume of the body immersed inside the fluid, nature (density) of the fluid and acceleration due to gravity

Note: If a body moves down with acceleration a (a<g) then buoyant force = V ρ(g-a)

<u>Density</u>

The density of a body is defined as the ratio of mass of the body to the volume occupied by the body.

$$\therefore \text{density} = \frac{mass}{volume} \Rightarrow \rho = \frac{M}{V}$$

Units: kgm^{-3} (in SI) : $gm\ cm^{-3}$ (in CGS)
$1 gm/cc = 10^3 kg/m^3$
Dimensional formula = ML^{-3}
Density is a scalar quantity

<u>Density of a mixture</u>

- When two liquids of masses m_1, m_2 and densities ρ_1, ρ_2 respectively are mixed then the effective density of the mixture is

$$\rho = \frac{M}{V} = \frac{M_1+M_2}{V_1+V_2} = \frac{m_1+m_2}{\left(\frac{m_1}{\rho_1}+\frac{m_2}{\rho_2}\right)} = \frac{(m_1+m_2)\rho_1\rho_2}{m_1\rho_2+m_2\rho_1}$$

Note : i) If m_1=m_2 then $\rho = \frac{2\rho_1\rho_2}{\rho_1+\rho_2}$

ii) The above is true for any number of liquids

$$\rho = \frac{\sum M_1}{\sum\left(\frac{M_1}{\rho_1}\right)}$$

- When two liquids of volumes V_1, V_2 and densities ρ_1, ρ_2 respectively are mixed together, then the resultant density of the mixture is

$$\rho = \frac{m}{V} = \frac{m_1+m_2}{V_1+V_2} = \frac{V_1\rho_1+V_2\rho_2}{V_1+V_2}$$

Note: If $V_1 = V_2$ then, $\rho = \frac{\rho_1+\rho_2}{2}$

- The above is true for any number of liquids

$$\rho = \frac{\sum V_i\rho_i}{\sum V_i}$$

Variation of density with temperature:

In general, with increase in temperature due to the expansion, the volume increases while mass remaining the same, thus the density will decrease

$$\rho_0 = \rho(1+\gamma\Delta t) \Rightarrow \rho = \frac{\rho_o}{(1+\rho\Delta t)} = \rho_0\left(1-\rho\Delta t\right)$$

Where ρ_0 = density at 0^0C

ρ = density at desired temp

γ = coefficient of cubical expansion

Δt = rise in temperature

Variation of density with pressure:

With increase in pressure, volume decreases density increases:

$$\rho_0 = \rho\left[1-\frac{\Delta p}{K}\right]$$

$$\Rightarrow \rho = \rho_0\left[1-\frac{\Delta p}{k}\right]^{-1} = \rho_0\left(1+\frac{\Delta p}{k}\right)$$

Where ρ_o = density at NTP

ρ = density at desired pressure

Δp = increase in pressure

K = Bulk Modulus

Relative density (Specific gravity)

$$\text{RD} = \frac{\textit{density of the body}}{\textit{density of water at } 4^0 C}$$

$$= \frac{\textit{Mass of the body}}{\textit{Mass of equal volume of water at } 4^0 c}$$

$$\text{RD} = \frac{\textit{weight of the body}}{\textit{weight of equal volume of water at } 4^0 c}$$

$$\text{RD} = \frac{\textit{weight of the body}}{\textit{upthrust exerted by water}}$$

$$= \frac{\textit{weight of the body}}{\textit{Apparent loss of weight in water}}$$

$$\text{RD} = \frac{\textit{weight of the body in air}}{\textit{weight of body in air} - \textit{weight of the body in water}}$$

$$\text{R.D.} = \frac{w_1}{w_1-w_2}$$

If loss of weight of a body in air is 'a' and that of in liquid is 'b' then,

$V\rho_w g = a;\ V\rho_L g = b$

RD of liquid =

$$\frac{\rho_L}{\rho_w} = \frac{\textit{loss of weight in liquid}}{\textit{loss of weight in water}} = \frac{b}{a} = \frac{W_{air}-W_{liquid}}{W_{air}-W_{water}}$$

Floatation:

When a body of density ρ_b and volume V immersed in a liquid of density ρ then forces acting are

- The weight of body acting vertical down wards through the center of gravity the body W = mg = $V\rho_b g$
- The upthrust acting upwards through center of gravity of displaced liquid called center of buoyancy Th = $V\rho g$

Due to the forces, following three situations are possible

- Density of body is greater than that liquid. Then weight will be more than upthrust and body will sink.

$\therefore \rho_b > \rho \Rightarrow W > Th \Rightarrow body$ sinks

- Density of the body is equal to that liquid. The weight is equal to that of liquid displaced. The weight is equal to thrust. Body will float fully submerged

$\therefore \rho_b = \rho \Rightarrow W = Th$

$\Rightarrow$ body floats fully immersed

- Density of the body is less than liquid. Weight is less than upthrust,

$\Rightarrow V\rho_b g = V_{in}\rho g \ \Rightarrow V\rho_b = V_{in}\rho$

Fraction of volume of the body outside the liquid:

A body of volume V and density ρ_b is floating in a liquid of density ρ with volume V_{in} immersed in the liquid

$$\therefore V\rho_b = V_{in}\rho$$

$$\therefore V_{out} = V - V_{in} = V\left(1-\frac{\rho_b}{\rho}\right)$$

$$f_{out} = \frac{V_{out}}{V_{in}} = \left(1-\frac{\rho_b}{\rho}\right)$$

Floating ice:

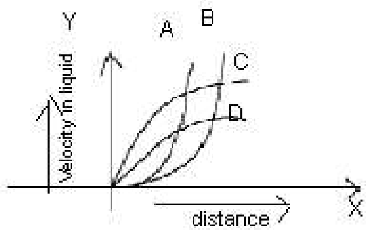
- When ice block floating in water melts the level of water in the vessel remains unchanged
- When ice block with cork floating in water melts, the level of water in the vessel remains unchanged
- When ice block with lead shot or metal ball floating in water melts, the level of water in the vessel decreases
- If a block of ice, floating in a liquid of density less than that of water, melts, then the liquid level falls
- If a block of ice, floating in a liquid of density greater than that of water, melts, then the liquid level rises.

CONCEPTUAL QUESTIONS

1. The main cause of viscosity is
   1. Force of repulsion between molecules
   2. Cohesive forces 3. adhesive forces
   4. both cohesive and adhesive forces.
2. As the depth of the river increases, the velocity of flow
   1. increases 2. decreases
   3. remains unchanged 4.may increase or decrease
3. Viscosity is the property by virtue of which a liquid
   1. occupies minimum surface area
   2. offers resistance for the relative motion between its layers.
   3. becomes spherical in shape
   4. tends to gain its deformed position.
4. Which of the following substances has the greatest viscosity?
   1. Mercury 2. Water
   3. Kerosine 4. Glycerine
5. Machine parts are jammed in winter due to
   1. increase in viscosity of lubricant
   2. decrease in viscosity of lubricant
   3. increase in surface tension of lubricant
   4. decrease in surface tension of lubricant
6. Viscosity is most closely related to
   1. density 2. velocity 3. friction 4. energy
7. Clouds appear to float in air due to
   1. low density 2. Air current
   3. Viscosity of air 4. Buoyancy
8. Rain drops fall with terminal velocity due to
   1. Buoyancy 2. Viscosity
   3. Low weight 4. surface tension
9. The force which tends to destroy the relative motion between liquid layers is known as
   1. Force due to surface tension 2. Viscous force
   3. Gravitational force 4.Force of Cohesion
10. Two identical lead shots are dropped at the same time in two glass jars containing water and glycerine. The lead shot dropped in glycerine descends slowly because.
    1. Viscous force is more in water than in glycerine
    2. Viscous force is more in glycerine than in water
    3. Surface tension is more in water
    4. Surface tension is more in glycerine
11. After the storm, the sea water waves subside due to
    1. Surface tension of sea-water
    2. Disapperance of heavy currents
    3. The viscosity of sea water
    4. Gravitational pull of the storm
12. When a metallic sphere is dropped in a long column of a liquid, the motion of the sphere is opposed by the viscous force of the liquid. If the apparent weight of the sphere equals to the retarding forces on it, the sphere moves down with a velocity called.
    1. Critical velocity 2. Terminal velocity
    3. Velocity gradient 4. Constant velocity
13. The tangential forces per unit area of the liquid layer required to maintain unit velocity gradient is known as
    1. Coefficient of gravitation of liquid layer
    2. Coefficient of friction between layers
    3. Coefficient of viscosity of the liquid
    4. Temperature coefficient of viscosity
14. The quality of fountain-pen ink depends largely on
    1.Surface tension of the liquid 2. Viscosity of ink
    3. impurities in ink 4. Density of ink
15. The tangential force (or) viscous force on any layer of the liquid is directly proportional to velocity gradient $\left(\frac{dv}{dx}\right)$. Then the direction of velocity gradient is :
    1. Perpendicular to the direction of flow of liquid
    2. Parallel to the direction of flow of liquid
    3. Opposite to the direction of flow of the liquid
    4. independent of the direction of flow of liquid.
16. If the flow is stream lined then Reynold number is less than
    1. 2000 2. 3000 3. 1000 4. 4000
17. Viscosity of the fluids is analogous to
    1. Random motion of the gas molecules
    2. Friction between the solid surfaces
    3. integral motion
    4. Nonuniform motion of solids

18. After terminal velocity is reached the acceleration of a body falling through a viscous fluid is :
1. zero 2. g 3. less than g 4. greater than g

19. A small ball is dropped in a viscous liquid. Its fall in the liquid is best described by the figure



1. Curve A 2. Curve B 3. Curve C 4. Curve D

20. Unit of coefficient of viscosity is :
1. pascal-second 2. poise
3. $Ns\,m^{-2}$ 4. 1, 2, 3

21. Coefficient of kinematic viscosity is, (η is the Coefficient of viscosity and ρ is the density of the liquid)
1. $\frac{\eta}{\rho}$ 2. $\eta\rho$ 3. $\frac{\rho}{\eta}$ 4. $\frac{\eta}{S\rho}$

22. The viscous drag is
1. inversely proportional to the velocity gradient
2. directly proportional to the surface area of layers in contact
3. independent of nature of liquid
4. perpendicular to the directionof liquid flow

23. For an ideal fluid, viscosity is
1. zero 2. infinity 3. finite but small 4. unity

24. When stirring of a liquid is stopped, the liquid comes to rest due to
1. surface tension 2. gravity
3. viscosity 4. buoyancy

25. Viscosity is exhibited by
1. Solids, liquids, and gases. 2. liquids and gases
3. Solids and gases 4. Solids and liquids

26. A good Lubricant must have
1. high viscosity 2. low viscosity
3. high density 4. low surface tension

27. With the increase of temperature,
1. The viscosity of a liquid increases
2. The viscosity of a liquid decreases
3. The viscosity of a gas decreases
4. The viscosity of a gas remains unchanged.

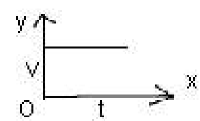
28. Coefficient of viscosity of a gas
1. increases with increase of temperature
2. decreases with increase of temperature
3. remains constant with increase of temperature
4. may increase or decrease with increase of temperature.

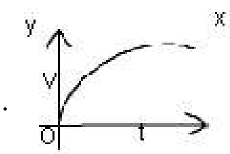
29. If air is blown with a straw under of the pans of a physical balance present in equilibrium position, then that pan.
1. rises up 2. remains in the same position
3. lowers down
4. rises or lowers depending upon the velocity of air blown.

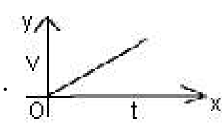
30. Viscosity of water at constant temperature is
1. more in deep water 2. more in shallow waters
3. less in deep water
4. same in both deep water and shallow waters

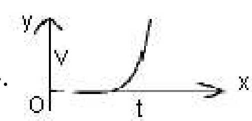
31. Hot syrup flows faster because
1. Surface tension increases 2. Viscosity decreases
3. Viscosity increases
4. Surface tension decreases.

32. A ball is dropped into coaltar. Its velocity-time curve will be

1. 

2. 

3. 

4. 

33. The force of buoyancy is equal to
1. Weight of the body
2. Weight of the liquid displaced by the body
3. apparent weight of the body
4. viscous force

34. The weight of the body is maximum in
1. air 2. hydrogen 3. water 4. vacuum

35. When a boat in a river enters the sea water, then it
1. sinks a little 2. rises a little
3. remains same 4. will drown

36. When a body is fully immersed in a liquid, the loss of weight of the body is equal to
1. apparent weight of the body
2. force of buoyancy
3. half the force of buoynacy
4. twice the force of buoyancy

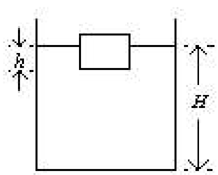
37. A boat full of scrap iron is floating on water in a lake. If all the iron is dropped into the water, the level of water will
1. go up 2. fall down
3. remain the same 4. Can not be decided.

38. A large block of ice floats in a liquid. When ice melts, the liquid level rises. The density of liquid is
1. greater than that of water 2. less than that of water
3. equal to that of water 4. half of that of water

39. Consider the following two statements and identify the correct choice.
A: When a body floats in a liquid, it displaces the liquid whose weight is equal to its own weight.
B: When a body sinks in a liquid,it displaces the liquid whose volume is equal to its own volume.
1. A is true but B is false 2. A is false but B is true
3. Both A and B are true 4.Both A and B are false.

40. 100 kg of iron and cotton are weighed by using a spring balance on the surface of the earth. If R_1 and R_2 are the readings shown by the balance, then
1) $R_1 < R_2$ 2) $R_1 = R_2$ 3) $R_1 > R_2$ 4) $R_1 = R_2 = 0$

41. A wooden block, floats in water contained in a beaker as shown in the figure. If a coin is placed on the top of the block, what happens to the values of 'h' and 'H' shown in the figure?



1) 'h' increases, 'H' decreases
2) 'h' increases, 'H' increases
3) 'h' decreases, 'H' decreases
4) 'h' decreases, 'H' increases

42 As a swimmer goes from the surface of water to a depth of 20m, the change in the pressure on his body is nearly
1) 3 atmospheres 2) 1 atmosphere
3) 2 atmospheres 4) zero

43. A bucket of water contains a wooden block floating in water with (4/5)th of its volume sub merged in the water. The bucket is placed on the floor of a lift and the lift now starts moving down with uniform acceleration. The block of wood now
1) moves upward 2) moves downward
3) remains at same place 4) moves horizontally

44. The pressure at a depth 'h' in a liquid of density "ρ" is plotted on the Y-axis and the value of 'h' on the X-axis , the graph is a straight line. The slope of the straight line is
(g = acceleration due to gravity)
1) ρ g 2) 1/ρ g 3) ρ/g 4) g/ρ

45. A drop of water of radius "r" is falling through the air of coefficient of viscosity 'η' with a constant velocity of 'v'. The resultant force on the drop is
1) $\frac{1}{6\pi\eta rv}$ 2) $6\pi\eta rv$
3) $\sqrt{6\pi\eta rv}$ 4) zero

46. If air is blown through the space between a calendar suspended from a nail on wall and the wall, then
1. The calendar moves close to the wall.
2. The calendar moves farther from the wall.
3. The position of the calendar does not change.
4. The position of the calendar may or maynot change.

47. A spinning ball is moving in a direction opposite to the direction of the wind. The ball moves in a curved path as
1. The pressure at the top and the bottom of the ball are equal.
2. The pressure at the top > the pressure at the bottom
3. The pressure at the top < the pressure at the bottom
4. There is no relation between the pressures.

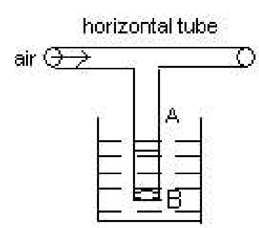
48. The dynamic lift of an aeroplane is based on
1. Torricelli theorem 2. Bernoulli's theorem
3. Conservation of angular Momentum
4. Principle of continuity.

49. A gale is on a house. The force on the roof due to the gale is
1. directed downward 2. zero
3. directed upward 4.information insufficient

50. A train goes past a person standing at the edge of a platform at high speed. Then the person will be
1. attracted towards the train
2. unaffected by the train 3. reflected by the train
4. affected only if its speed is greater than critical velocity.

51. The velocity distribution curve of the stream line flow of a liquid advancing through a capillary tube is
1. Circular 2. eliptical
3. parabolic 4. a straight line

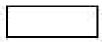
52. Water stands at level A in the arrangement shown in figure . If a jet of air is gently blown into the horizontal tube in the direction shown in figure, then



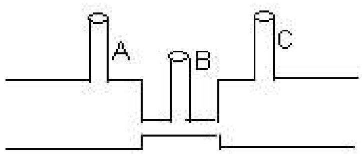
1. Water will fall below A in the capillary tube
2. Water will rise above A in the capillary tube
3. There will be no effect on the level of water in the capillary tube
4. Air will emerge from end B in the form of bubbles.

53. Vertical sections of a wing of a fan are shown in the following figures. The maximum up thrust will be in figure.

1.  2. 

3.  4. 

54. Three tubes A, B, C are connected to a horizontal pipe in which liquid is flowing. The radii of the pipes at the joints of A, B and C are 2 cm, 1 cm and 2 cm respectively. The height of the liquid



1. in A is maximum 2. in A and C is equal
3. is same in all the three 4. in A and B is same

55. Poiseuili's equation holds good when
1. the flow is steady and stream line
2. the pressure is constant at every cross section
3. The liquid in contact with the walls is stationary
4. 1, 2, 3.

56. A car moving on a road when overtaken by a bus
1. is pulled towards the bus
2. is pulled away from the bus
3. is not affected by the bus
4. information is insufficient.

57. Stream line motion becomes turbulent motion when the velocity of the liquid is
1. beyond critical velocity 2. critical velocity
3. below critical velocity 4. variable velocity

58. The rate of flow of the liquid is the product of
1. Area of cross section of the liquid and velocity of the liquid.
2. Length of the tube of the flow and velocity of the liquid.
3. Volume of the tube of the flow and velocity of the liquid.
4. Viscous force acting on the liquid layer and velocity of the liquid

59. The equation of continuity leads to
1. Law of conservation of moments of liquid flow.
2. law of conservation of energy
3. law of equipertition of energy
4. law of conservation of mass distribution.

60. The volume of liquid flowing per second out of an orifice at the bottom of the tank does not depend upon
1. the density of the liquid
2. acceleration due to gravity
3. the height of the liquid above orifice
4. the area of the orifice

61. Water is flowing in a pipe of uniform cross section under constant pressure. At some place the pipe becomes narrow. The pressure of water at this place.
1. remains same 2. may increase or decrease
3. increases 4. decreases.

62. Water flows through a horizontal pipe of radius 'r' at a speed V. If the radius of the pipe is doubled, the speed of flow of water under similar conditions is

1. 2V 2. $\frac{V}{2}$ 3. $\frac{V}{4}$ 4. 4V

63. A liquid is under stream lined motion through a horizontal pipe of nonuniform cross section. If the volume rate of flow at cross section 'a' is V, the volume rate of flow at cross section $\frac{a}{2}$ is

1. $\frac{V}{2}$ 2. V 3. $\frac{V}{4}$ 4. V

64. Bernoulli's theorem is applicable in the case of
1. Compressible liquid in stream lined flow
2. Compressible liquid in turbulent flow
3. incompressible liquid in stream lined flow
4. incompressible liquid in turbulent flow.

65. In turbulent flow, the velocity of the liquid molecules in contact with the walls of the tube.
1. is zero 2. is maximum
3. is equal to critical velocity
4. may have any value

66. Which of the following is a characteristic of turbulent flow?
1. velocity more than critical velocity
2. irregular flow
3. molecules crossing from one layer to the other
4. 1, 2, 3.

67. When the value of Reynold's number is less, the predominant forces are
1. Viscous forces 2. inertial forces
3. Surface tension forces 4. gravitational forces

68. The liquid flow is most stream lined when
1. liquid of high viscosity and high density flowing through a tube of small radius.
2. liquid of high viscosity and low density flowing through a tube of small radius
3. liquid of low viscosity and low density flowing through a tube of large radius
4. liquid of low viscosity and high density flowing through a tube of large radius

69. The rate of flow of a liquid through a capillary tube is
1. directly proportional to the length of the tube
2. inversely proportional to the difference of pressure between the ends of the tube.
3. directly proportional to the 4th power of the radius of the tube.
4. independent of the nature of the liquid

70. If l is length of the tube and r is the radius of the tube, then the rate of volume flow of a liquid is maximum for the following measurements, under the same pressure difference.

1. l, r 2. $\frac{l}{2}, 2r$ 3. $2l, \frac{r}{2}$ 4. $2l, 2r$

71. The paint -gun works on the principle of
1. Boyle's law 2. Bernoulli's principle
3. Archimedi's principle
4. Newton's laws of motion

72. A liquid flows through two capillary tubes fitted horizontally side by side to the bottom of a vessel containing liquid. Their lengths are l and 2l and radii are r and 2r respectively. If 'V' is the volume of the liquid that fows through the first tube in one minute, the time required for the same volume of liquid to flow through the second tube is

1. 8 minute 2. $\frac{1}{8}$ minute
3. $\frac{1}{4}$ minute 4. 4 minute

73. Which factor controls better the flow rate of a liquid through the syringe?
1) the pressure exerted by the thumb
2) the length of the needle
3) the nature of the liquid
4) the radius of the syringe bore.

74. In a laminar flow at a given point the magnitude and direction of the velocity of the fluid
1) both are constant
2) magnitude is only constant
3) direction is only constant.
4) both are not constant.

KEY

1.2	2.2	3.2	4.4	5.1
6.3	7.3	8.2	9.2	10.2
11.3	12.2	13.3	14.2	15.1
16.2	17.2	18.1	19.3	20.4
21.1	22.2	23.1	24.3	25.2
26.1	27.2	28.1	29.3	30.1
31.2	32.2	33.2	34.4	35.2
36.2	37.2	38.1	39.3	40.3
41.2	42.3	43.3	44.1	45.4
46.1	47.2	48.2	49.3	50.1
51.3	52.2	53.1	54.2	55.4
56.1	57.1	58.1	59.4	60.1
61.4	62.3	63.4	64.3	65.4
66.4	67.1	68.2	69.3	70.2
71.2	72.2	73.4	74.2	

NUMERICAL QUESTIONS
LEVEL - I

VISCOUS FORCE:

1. A metal plate of area 10^{-2} m^2 is placed on a liquid layer of thickness 2×10^{-3} m. If the liquid has coefficient of viscosity 2 S.I units the force required to move the plate with a velocity of 3 cm s^{-1} is
1. 0.3N 2. 0.03 N 3. 3 N 4. 30 N

2. A metal plate of area 400 cm^2 is placed on a glycerine layer of thickness 5 mm. $\left(\eta_{glycerine} = 2\,pa\ s\right)$ The horizontal force required to move the plate with a velocity of 5 cms^{-1} is --- newton.
1. 1 2. 0.8 3. 0.5 4. 8

3. The velocity of water in a river is 18 kmph near the surface. If the river is 4m deep, the shearing stress between horizontal layers of water in Nm^{-2} is ($\eta_{water} = 1\times10^{-3}\ pa.s$)
1. 2.5×10^{-3} 2. 1.25×10^{-3} 3. 0.75×10^{-3} 4. zero

4. If the shearing stress between the horizontal layers of water in a river is 1.5 milli newton/ m^2 and $\eta_{water} = 1\times10^{-3}\ pa.s$, The velocity gradient is ... s^{-1}
1. 1.5 2. 3 3. 0.7 4. 1

5. A force of 10N is required to draw rectangular glass plate on the surface of a liquid with some velocity. Force needed to draw another glass plate of 3 times length and 2 times width is
1) 5/3N 2) 10N 3) 60N 4) 30N

6. Two flat plates are separated by a layer 4mm thick liquid. The upper plate is moved by force of 400 dynes with a velocity of 10 cm/s. If the area of the upper plate is 5cm^2, the coefficient of viscosity of the liquid is
1) 3.2 poise 2) 1.6 poise 3) 32 poise 4) 16 poise

POISEUILLE'S EQUATION

7 The vein of a person is horizontal and its length is 0.314 m. It has an internal radius of 1 mm. The average blood flow through the vein is 5 cms^{-1}. The rate of flow of blood in 10^{-7}m^{3}s^{-1} is
1. 1.57 2. 0.157 3. 15.7 4. 0.0157

8. Water is flowing through a capillary tube at the rate of $20\times10^{-6}\,m^3s^{-1}$. If an identical tube is connected in series, the rate of flow of water in m^3s^{-1} is
1. 20×10^{-6} 2. 40×10^{-6} 3. 0 4. 10×10^{-6}

9. Water is flowing through a capillary tube at the rate of 20 x 10^{-6} m^3/s. Another tube of same radius and double the length is connected in series to the first tube. Now the rate of flow of water in m^3s^{-1} is
1. 10×10^{-6} 2. 3.33×10^{-6}
3. 6.67×10^{-6} 4. 20×10^{-6}

10. The total area of cross section is 0.25 m^2. If blood is flowing at the rate of 100 cm^3s^{-1}, then the average velocity of flow of blood through the capillaries, in mms^{-1} is
1. 0.4 2. 4 3. 25 4. 400

11. Water flows through a capillary tube at the rate of 10cc per minute. If the pressure difference across the same tube is doubled, the rate of flow of water through the tube will be (in cc per minute)
1. 20 2. 5 3. 40 4. 2.5

12. The rate of flow of water in one minute through 1m length of a capillary tube of internal radius of 1mm, if the pressure across the ends of the tube is 5 cm of Hg is about (η for water is 0.8 centi poise)
1. 17 ml 2. 200 ml 3. 22ml 4. 15 ml

13. An artery in a certain person has been widened $1\frac{1}{2}$ times the original diameter. If the pressure difference across the artery is maintained constant, the blood flow through the artery will be increased
1. $\frac{3}{2}$ times 2. $\frac{9}{4}$ times 3. no change 4. $\frac{81}{16}$ times

14. The rate at which water flows through a capillary of length 0.5 m with an internal diameter of 1mm, coefficient of viscosity $1.3\times10^{-3}\,kg.m^{-1}s^{-1}$ and pressure head 20 cm of water in c.c. per second is.
1. 7.4×10^{-2} 2. 3.7×10^{-2} 3. 74×10^{-2} 4. 7.4

15. Water flowing from a hose pipe fills a 15 litre container in one minute. The speed of water from the free opening of radius 1 cm is (in ms^{-1})
1. 2.5 2. $\frac{\pi}{2.5}$ 3. $\frac{2.5}{\pi}$ 4. 5 π

16. Water flows with a velocity V in a tube of diameter d and the rate of flow is Q . Another tube of diameter 2d is coupled to the first one. The velocity of water flowing out and rate of flow in the second tube are respectively
1. $\frac{V}{4}$ and Q 2. $\frac{V}{2}$ and $\frac{Q}{2}$
3. 2 V and 2 Q 4. $\frac{V}{2}$ and 2 Q

17. Water flows through a capillary tube of length 20cm and radius of 1 mm under a constant pressure difference of 14 cm of water level.
If $\eta_{water} = 1\times10^{-3}\,pa\ s$; $g = 10ms^{-2}$, the rate of flow of water through the tube in m^3s^{-1} is
1. 27.5×10^{-7} 2. 275×10^{-7}
3. 275 4. 2.75×10^{-7}

18. Two liquids are allowed to flow through two capillary tubes of lengths in the ratio 1 : 2 and radii in the ratio 2 :3 under the same pressure difference. If the volume rates of flow of the liquids are in the ratio 8 : 9, the ratio of their coefficients of viscosity is
1. 1 : 3 2. 3 :1 3. 4 : 9 4. 9 : 4

19. The factor by which the pressure across a capillary tube is to be changed, so that the rate of flow of a liquid is doubled, when the length and the radius of the tube are doubled is
1) 4 2) 8 3) 1/ 8 4) ¼

20. The viscous resistance of a tube to liquid flow is R. Its resistance for a narrow tube of same length and 1/3 times radius is
1) R/3 2) 3R 3) 27R 4) 81R

21. The pressure exerted by water in a vessel at its bottom is 32 x 10^2 Nm^{-2}. A capillary tube of length 0.25 m and radius 1 mm is fixed near the bottom of the vessel to the side of the vessel. If volume of water flown out of the tube in 70 sec is 44 x 10^{-6} m^3, the coefficient of viscosity of water is
1) 8 x 10^{-3} Pa-s 2) 0.8 x 10^{-3} Pa-s
3) 560 x 10^{-3} Pa-s 4) 0.56 x 10^{-3} Pa-s

22. Three horizontal capillary tubes of same radii and lengths L_1, L_2 and L_3 are fitted side by side a little above the bottom, to the wall of a tank that is filled with water. The length of a single capillary tube of same radius that can replace the three tubes such that the rate of flow of water through the single tube equals the combined rate of flow through the three tubes is
1) $\frac{L_1L_2L_3}{L_1+L_2+L_3}$ 2) $\frac{L_1L_2L_3}{L_1L_2+L_2L_3+L_3L_1}$
3) $\frac{L_1+L_2+L_3}{L_1L_2L_3}$ 4) $\frac{L_1L_2+L_2L_3+L_3L_1}{L_1L_2L_3}$

BERNOULLI'S THEOREM & EQUATION OF CONTINUITY

23. Two water pipes of diameters 4cm and 8 cm are connected with main supply line. The velocity of flow of water in the pipe of 8 cm diameter is ---- times that of 4 cm diameter pipe.
1. 4 2. $\frac{1}{4}$ 3. 2 4. $\frac{1}{2}$

24. A liquid is flowing in a cylindrical pipe of internal diameter 4 cm with a velocity of 5m s^{-1}. If this tube is joined with another tube of internal diameter 2cm then the velocity of flow of liquid in the smaller tube will be (in ms^{-1})
1. 10 2.40 3.5 4.20

25. A horizontal pipe of non uniform cross section has water flow through it such that the velocity is $2ms^{-1}$ at a point where the pressure is 40 kpa. The pressure at a point where the velocity of water flow is 3 ms^{-1} is (in Kilopascal)

1. 27 2. 60 3. 37.5 4. 40

26. The velocity of the wind over the surface of the wing of an aeroplane is 80 ms^{-1} and under the wing 60 ms^{-1}. If the area of the wing is $4m^2$, the dynamic lift experienced by the wing is
[density of air = 1.3 kg. m^{-3}]

1. 3640 N 2. 7280 N
3. 14560 N 4. 72800 N

27. In a horizontal pipe line of uniform cross-section, pressure falls by 5Pa between two points separated by 1km. The change in the kinetic energy per kg of the oil flowing at these points is (Density of oil = $800kgm^{-3}$)

1) $6.25\times10^{-3}\,Jkg^{-1}$ 2) $5.25\times10^{-4}\,Jkg^{-1}$
3) $3.25\times10^{-5}\,Jkg^{-1}$ 4) $4.25\times10^{-2}\,Jkg^{-1}$

28. Water flows through a non-uniform tube of area of cross sections A, B and C whose values are 25, 15 and 35 cm^2 respectively. The ratio of the velocities of water at the sections A, B and C is

1) 5 : 3 : 7 2) 7 : 3 : 5
3) 21 : 35 : 15 4) 1 : 1 : 1

29. A liquid is kept in a cylindrical jar, which is rotated about the cylindrical axis. The liquid rises at its sides. The radius of the jar is 'r', and speed of rotation is 'ω'. The difference in height at the center and the sides of the jar is

1) $\frac{r^2\omega^2}{g}$ 2) $\frac{r^2\omega^2}{2g}$ 3) $\frac{g}{r^2\omega^2}$ 4) $\frac{2g}{r^2\omega^2}$

TORRICELLI'S THEOREM

30. A cylindrical tank of 1 meter radius rests on a platform 5m high. Initially the tank is filled with water to a height of 5m. A plug whose area is $10^{-4}\,m^2$ is removed from an orifice on the side of the tank at the bottom. The initial speed with which water flows out from the orifice in ms^{-1} is $\left(g = 10ms^{-2}\right)$

1. 10 2. 5 3. $5\sqrt{2}$ 4. $10\sqrt{2}$

31. In the above problem, the initial speed with which water strikes the ground in ms^{-1} is

1. 10 2. 5 3. $5\sqrt{2}$ 4. $10\sqrt{2}$

32. The level of water in a tank is 5m high. A hole of area of cross section 1 cm^2 is made at the bottom of the tank. The rate of leakage of water from the hole in m^3s^{-1} is ($g = 10ms^{-2}$)

1. 10^{-3} 2. 10^{-4} 3. 10 4. 10^{-2}

33. There is a hole at the side-bottom of a big water tank. The area of the hole is $4mm^2$. Throught it a pipe is connected. The upper surface of water is 5 m above the hole. The rate of flow of water through the pipe is (in m^3s^{-1}) ($g= 10ms^{-2}$)

1. 4×10^{-5} 2. 4×10^{5}
3. 4×10^{-6} 4. 28×10^{-6}

BUOYANCY & PRESSURE

34. A balloon contains $1000m^3$ of Hydrogen. If the mass of the balloon without gas is 100 kg the net lifting ability of the balloon is (in Kgwt.) (given density of Hydrogen is 0.09 $kg.m^{-3}$ and that of air is $1.3kg.m^{-3}$)

1. 2220 2. 1300 3. 190 4. 1110

35. A brass sphere weighs 100 gm.wt in air. It is suspended by a thread in a liquid of specific gravity = 0.8. If the specific gravity of brass is 8; the tension in the thread in newton is

1. 882 2. 8.82 3. 0.882 4. 0.00882

36. Two blocks A and B float in water. If block A floats with $\frac{1}{4}$th of its volume immersed and block B floats with $\frac{3}{5}$th of its volume immersed, the ratio of their densities is

1. 5 :12 2. 12 : 5 3. 3 :20 4. 20 : 3

37. A water filled cylinder of height 50 cm and base area 20 cm^2 is placed on a table with the base on the table. The thrust offered by water on the table is

1) 98N 2) 49N 3) 9.8N 4) 4.9 N

38. A cube of side 20cm is floating on a liquid with 5cm of the cube outside the liquid. If the density of liquid is 0.8 gm/c.c then the mass of the cube is

1) 4.2 kg 2) 4.8 kg 3) 5kg 4) 5.2 kg

39. If S_1 is the specific gravity of a solid with respect to a liquid and S_2 is the specific gravity of the liquid with respect to water, then the specific gravity of the solid with respect to water is

1) $S_1 + S_2$ 2) $S_1 \times S_2$ 3) $S_1 - S_2$ 4) S_1 / S_2

40. If a body floats with $(m/n)^{th}$ of its volume above the surface of water, then the relative density of the material of the body is

1) (n-m) / n 2) m/n
3) n/m 4) (n-m) / m

41. If the air density were uniform, then the height of the atmosphere above the sea level to produce a normal atmospheric pressure of 1.0×10^5 Pa is (density of air is 1.3 kg/m^3, g = $10m/s^2$)

1) 0.77km 2) 7.7 km 3) 77km 4) 0.077km

42. An air tight container having a lid with negligible mass and an area of $8cm^2$ is partially evacuated. If a 48N force is required to pull the lid off the container and the atmospheric pressure is 1.0×10^5 Ps, the pressure in the container before it is opened must be
1) 0.6atm 2) 0.5 atm 3) 0.4 atm 4) 0.2 atm

43. When a body lighter than water is completely submerged in water, the buoyant force acting on it is found to be 'n' times its weight. The specific gravity of the material of the body is

1) $\frac{1}{1+n}$ 2) $\frac{1}{n}$ 3) n 4) $n+\frac{1}{n}$

TERMINAL VELOCITY

44. Two equal drops of water are falling through air with a steady velocity of $10cms^{-1}$. If the drops recombine to form a single drop then the terminal velocity is

1) $2^{\frac{2}{3}} \times 5cms^{-1}$ 2) $2^{\frac{2}{3}} \times 10cms^{-1}$

3) $2^{\frac{2}{3}} \times 15cms^{-1}$ 4) $2^{\frac{2}{3}} \times 4cms^{-1}$

45. The velocity of a ball of mass 'm' density 'd_1' when dropped in a container filled with glycerin of density 'd_2' becomes constant after some time. The viscous force acting on the ball will be

1) $mg\left(\frac{d_1}{d_2}\right)$ 2) $mg\left(1-\frac{d_2}{d_1}\right)$

3) $mg\left(\frac{d_1+d_2}{d_1}\right)$ 4) $mg\left(\frac{d_1+d_2}{d_2}\right)$

KEY

1.1	2.2	3.2	4.1	5.3	6.1
7.1	8.4	9.3	10.1	11.1	12.2
13.4	14.1	15.3	16.1	17.1	18.3
19.4	20.4	21.1	22.2	23.1	24.4
25.3	26.2	27.1	28.3	29.2	30.1
31.4	32.1	33.1	34.4	35.3	36.1
37.3	38.2	39.2	40.1	41.2	42.3
43.2	44.2	45.2			

LEVEL - II

POISEUILLE'S EQUATION

1. Three capillaries of same length but radii 2r, 3r, 4r are connected in series and a liquid flows through them in stream line flow. If the pressure across the third capillary is 16 mm of Hg the pressure across the first capillary will be (in mm of Hg)
1. 25.6 2. 2.56 3. 256 4. 2560

2. A tube of radius R and length L is connected in series with another tube of radius $\frac{R}{2}$ and length $\frac{L}{8}$. If the pressure across the tubes taken together is P, the pressure across the two tubes seperately are :

1. $\frac{P}{2}$ and $\frac{P}{2}$ 2. $\frac{P}{3}$ and $\frac{3P}{2}$

3. $\frac{P}{4}$ and $\frac{3P}{2}$ 4. $\frac{P}{3}$ and $\frac{2P}{3}$

3. A capillary tube is attached horizontally at a constant head arrangement. If the radius of the capillary tube is increased by 10%, the rate of flow of liquid changes by about
1. -40% 2. +40% 3. +21% 4. +46%

4. A volume V of viscous liquid flows per unit time due to a pressure head ΔP along a pipe of diameter D and length L. Instead of this pipe a set of 4 pipes each of diameter $\frac{D}{2}$ and length $2L$ is connected to the same pressure head ΔP. Now, the volume of the liquid flowing per unit time is

1. V 2. $\frac{V}{4}$ 3. $\frac{V}{8}$ 4. $\frac{V}{16}$

5. When a capillary tube is connected to a pressure head, V c.c. of water flows per second. If a tube of same length but half the radius is connected to the same pressure head, the quantity of water flowing through the tube per second will be (in c.c)

1. $\frac{V}{4}$ 2. V 3. $\frac{V}{16}$ 4. $\frac{V}{8}$

6. When a capillary tube is connected to a pressure head V.c.c. of water flows per second. If another tube of same length but half the radius is connected to the first in series to the same pressure head, the quantity of water flowing through them per second will be (in c.c)

1. $\frac{V}{16}$ 2. $\frac{V}{17}$ 3. $\frac{17V}{16}$ 4. V

7. When a capillary tube is connected to a pressure head V c.c of water flow per second. If another tube of same length but half the radius is connected parallel to the first one, the quantity of water flowing through them per second will be (in c.c)

1. $\frac{V}{17}$ 2. $\frac{V}{16}$ 3. $\frac{16V}{17}$ 4. $\frac{17V}{16}$

8. A large bottle is fitted with a capillary tube at the bottom. The ratio of times taken to empty the bottle when it is first filled with water and next with oil of relative density 0.8 is

[$\eta_{water} = 10^{-3}$ pas $\eta_{oil} = 2\times10^{-3}$ pas]
1. 2 : 5 2. 2 : 3 3. 3 : 4 4. 1 : 2

9. A liquid flows through two capillary tubes connected in series. Their lengths are 4l and l and radii are 2r and r respectively. The ratio of the pressure differences across the first and 2nd tube is

1. 1 :4 2. 1 : 64 3. 8 :1 4. 1 :1

10. Two capillary tubes of same length and radii r_1, r_2 are fitted horizontally side by side(in parallel) to the bottom of a vessel containing water. The radius of a single tube that can replace the two tubes such that the rate of steady flow through this tube equals the combined rate of flow through the tube is

1) $\left(r_1^2+r_2^2\right)^{\frac{1}{2}}$ 2) $\left(r_1^3+r_2^3\right)^{\frac{1}{3}}$

3) $\left(r_1+r_2\right)^{\frac{1}{2}}$ 4) $\left(r_1^4+r_2^4\right)^{\frac{1}{4}}$

11. The mass of water flowing in 10 minutes through a tube 0.1 cm in diameter, 40 cm long if there is a constant pressure head of 20cm of water, is (η for water = 0.008 C.G.S units and (g = 1000 cms^{-2})

1) 19.3π gm 2) (29.3) π gm
3) 49.3 π gm 4) 59.3 π gm

12. When water (η=0.01 poise) and benzene (η=0.0065 poise) are allowed to flow through a capillary tube it was found that the same amount of liquids are collected in the same time. But the pressures that caused the flow are different. If the pressure on water is 0.015atm. then the pressure on benzene is

1) $975\times10^{-4}\,atm$ 2) $975\times10^{-5}\,atm$
3) $975\times10^{-6}\,atm$ 4) $975\times10^{-7}\,atm$

13. When kerosene and coconut oil of coefficients of viscosity 0.002 and 0.0154 Nsm^{-2} are allowed to flow through the same pipe under the same pressure difference in the same time interval, the coconut oil collected is 1 litre in volume. The volume of kerosene that flows is

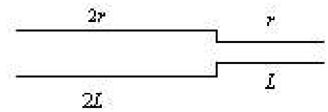
1) 5.5 lit 2) 6.6 lit 3) 7.7 lit 4) 8.8 lit

14. A square hole of side 'a' is made at a depth 'h' below water surface and to the side of a water container another circular hole of radius 'r' is made to the same container at a depth of '4h'. It is found that volume flow rate of water through both the holes is found to be same then

1) $r=\dfrac{a}{2\sqrt{\pi}}$ 2) $a=\dfrac{r}{2\sqrt{\pi}}$

3) $a=\dfrac{r}{\sqrt{2\pi}}$ 4) $r=\dfrac{a}{\sqrt{2\pi}}$

15. A horizontal composite capillary tube has a radius '2r' for a length '2L' and radius 'r' for a length 'L' as shown and is connected to a tank at one end and left free at the other end. The tank contains a liquid of coefficient of viscosity 'η'. If a constant pressure difference 'P' exists across the ends of the capillary tube, the volume flux through the capillary tube is



1) $\left(\dfrac{16}{17}\right)\dfrac{\pi \Pr^4}{8\eta L}$ 2) $\left(\dfrac{9}{8}\right)\dfrac{\pi \Pr^4}{8\eta L}$

3) $\left(\dfrac{17}{16}\right)\dfrac{\pi \Pr^4}{8\eta L}$ 4) $\left(\dfrac{8}{9}\right)\dfrac{\pi \Pr^4}{8\eta L}$

BERNOULLI'S THEOREM

16. A room has a window of area 'A'. Out side of the room wind is blowing parallel to the window with a velocity 'v'. If the density of air is 'ρ', then the force acting on the window is

1) $\dfrac{1}{2}\dfrac{\rho v^2}{A}$ 2) $\dfrac{1}{2}\rho v^2 A$

3) $\rho v^2 A$ 4) $2\rho v^2 A$

17. Water flowing steadily through a horizontal pipe of non-uniform cross section. If pressure of water is $4\times10^4\,N.m^{-2}$ at a point where cross section is 0.02 m^2 and velocityof flow is 2 ms^{-1}, the pressure at a point of cross sectional area 0.01 m^2 in $N.m^{-2}$ is :

1. 4.6×10^4 2. 3.4×10^4 3. 4×10^4 4. 2×10^4

18. The pressure that will be built up by a compressor in a paint-gun when a stream of liquid paint flows out with a velocity of 25 ms^{-1} (density of paint is 0.8 gm cm^{-3}) is (in Nm^{-2})

1. 2.5×10^2 2. 2.5×10^3 3. 2.5×10^5 4. 5×10^5

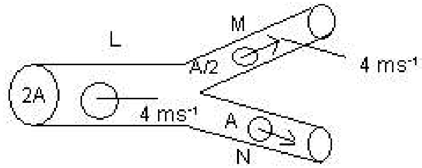
19. At a point P in a water pipe line the velocity is 1 ms^{-1} and the pressure is $3\times10^5\,pa$. At another point Q the area of cross section is half that of at P and the pressure is $5\times10^5\,pa$. The difference of heights between P and Q in metre is (g = 10 ms^{-2})

1. 10.5 2. 20.15 3. 4.5 4. zero

20. An aeroplane of mass 5000 kg is flying at an altitude of 3 km. If the area of the wings is 50m^2 and pressure at the lower surface of wings is $0.6\times10^5\,pa$, the pressure on the upper surface of wings is (in pascal) (g= 10 ms^{-2})

1. 59×10^3 2. 2×10^4
3. 6×10^4 4. 59

21. An incompressible liquid flows through a horizontal tube L M N as shown in the figure. Then the velocity'V' of the liquid through the tube N is :



1. $1ms^{-1}$ 2. $2\ ms^{-1}$ 3. $4.5\ ms^{-1}$ 4. $6ms^{-1}$

22. The pressure difference across a pipe of length 5 cm is 2×10^3 pa. Work done by the pressure in forcing $2m^3$ of water through the pipe in joule is :
1. 4×10^5 2. 2×10^5 3. 2×10^4 4. 4×10^3

23. In a horizontal oil pipe line of constant cross sectional area the decrease of pressure between two points 100 km apart is 1500 pa. The loss of energy per unit volume per unit distance is ---- Joule.
1. 15 2. 0.015 3. 0.03 4. zero

24. The reading of a manometer fitted to a closed tap is $3.5 \times 10^5\ Nm^2$. If the valve is opened the reading of the manometer falls to $3 \times 10^5\ Nm^2$. The velocity of water is
1. $0.1ms^{-1}$ 2. $1ms^{-1}$
3. $10ms^{-1}$ 4. $100\ ms^{-1}$

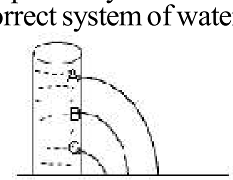
25. The loss of energy (E) of a liquid in a streamline flow, is related to the velocity (V) as
1. $E\alpha V^2$ 2. $E\alpha V$
3. $E\alpha\sqrt{V}$ 4. $E\alpha V^{\frac{3}{2}}$

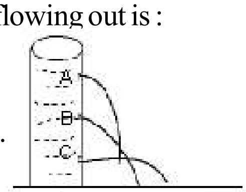
26. The pressure at the top of a building of height 200m is 500kPa. The minimum pressure required at the base of the building to pump water to a closed tank on the top of the building (g= 10 m/s^2)
1) $2.5\times10^4\ Pa$ 2) $2.5\times10^5\ Pa$
3) $2.5\times10^6\ Pa$ 4) $2.5\times10^3\ Pa$

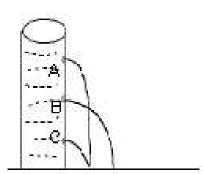
TORRICELLI'S THEOREM

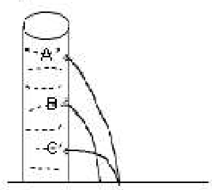
27. A tank with vertical walls is mounted so that its base is at a height of 1.2 m above the horizontal ground. The tank is filled with water to a depth 2.8m. A hole is punched in the side wall of the tank at a depth x m below the surface of water to have maximum range of the emerging stream. Then the value of x in meter is
1. 4.0 2. 1.6 3. 2.0 4. 2.3

28. Water stands at a height of 100 cm in a vessel whose side walls are vertical. A , B and C are holes at height 80cm, 50 cm, and 20 cm respectively from the bottom of the vessel. The correct system of water flowing out is :

1. 

2. 

3. 

4. 

29. Two identical tall jars are filled with water to the brim. The first jar has a small hole on the side wall at a depth h/3 and the second jar has a small hole on the side wall at a depth of 2h/3, where 'h' is the height of the jar. The water issuing out from the first jar falls at a distance R_1 from the base and the water issuing out from the second jar falls at a distance R_2 from the base. The correct relation between R_1 and R_2 is
1) $R_1 > R_2$ 2) $R_1 < R_2$
3) $R_2 = 2 \times R_1$ 4) $R_1 = R_2$

30. There is a hole at the bottom of a large open vessel .If water is filled upto a height h, it flows out in time 't' .If water is filled to a height 4h, it will flow out in time
1) 4t 2)t/4 3)t/2 4)2t

BUOYANCY

31. When a polar bear jumps on to an ice-berg, its weight 200 kg.wt. is just sufficient to sink the ice-berg. Then the weight of ice-berg is (specific gravity of ice = 0.9; Sp.gr.of sea water = 1.02)
1. 1500 kg.wt. 2. 1000kg.wt.
3. 3000 kg.wt. 4. 2040 kg.wt.

32. A large block of ice 4 m thick has a vertical hole drilled through it and is floating in the middle of water in a lake. The minimum length of rope required to scoop up a bucket full of water through the hole is (density of ice = 0.9 CGS unit, density of water = 1 CGS unit)
1. 40 cm 2. 24 cm 3. 20 cm 4. 360 cm

33. A sphere of density d is let fall in a liquid of density $\frac{d}{4}$. The acceleration of the body will be
1. $\frac{g}{4}$ 2. $\frac{3g}{4}$ 3. $\frac{g}{2}$ 4. g

34. A boat having length 2m and width 1m is floating in a lake. When a man stands on the boat, it is depressed by 3 cm. The mass of the man is
1) 50kg 2) 55kg 3) 60 kg 4) 70 kg

35. When equal volumes of two liquids are mixed, the specific gravity of mixture is 7/2. When equal masses of the same two liquids are mixed the specific gravity is 12/7. The specific gravities of two liquids are
1) 1 and 6 2) 2 and 6 3) 2 and 4 4) 3 and 6

36. A cube of wood supporting 200g mass just floats in water. When the mass is removed, the cube rises by 1cm, the linear dimension of cube is
1) 10cm 2) 20cm 3) $10\sqrt{2}$ cm 4) $5\sqrt{2}$ cm

37. A hollow metal sphere is found to float in water with the highest point just touching the free surface of water. If 'd' is the density of the metal in cgs units, the fraction that represents the volume of the hollow in terms of the volume of the sphere is
1) $\frac{1}{d}$ 2) $\left(1-\frac{1}{d}\right)$ 3) $\frac{d}{(d-1)}$ 4) $\left(1+\frac{1}{d}\right)$

38. A solid body is found floating in water with $\left(\frac{\alpha}{\beta}\right)^{th}$ of its volume submerged. The same solid is found floating in a liquid with $\left(\frac{\alpha}{\beta}\right)^{th}$ of its volume above the liquid surface. The specific gravity of the liquid is

1) $\frac{\beta-\alpha}{\alpha}$ 2) $\frac{\alpha-\beta}{\beta}$ 3) $\frac{\alpha}{\beta-\alpha}$ 4) $\frac{\beta}{\alpha-\beta}$

39. A wooden cube is found to float in water with ½ cm of its vertical side above the water. On keeping a weight of 50gm over its top, it is just submerged in the water. The specific gravity of wood is

1) 0.8 2) 0.9 3) 0.85 4) 0.95

40. A solid sphere of radius 'R' has a concentric cavity of radius 'R/2' inside it. The sphere is found to just float in water with the highest point of it touching the water surface. The specific gravity of the material of the sphere is

1) 1 2) 7/8 3) 8/7 4) 8/9

41. A rectangular block of wood of density 800kgm^{-3} having a mass of 2kg is pushed in to water so that it is completely submerged and then released. Neglecting viscous forces, the initial acceleration of the block will be (g = 10 m/s^2)

1) 1.25 m/s^2 downward 2) 2.5 m/s^2 upward
3) 1.25 m/s^2 upward 4) 2.5 m/s^2 downward

42. A tall measuring jar contains ethyl alcohol of density 0.8 gm/cm^3. An iron ball is dropped in to it and the level rises by 20 cm^3. The buoyant force acting on the ball is

1) 0.2N 2) 0.25 N 3) 0.16N 4) 1.6N

43. A vessel contains oil (density 'd') over mercury (density 'D'). A homogenous solid sphere floats with half of its volume in mercury and the other half in the oil. The density of the material of the sphere is

1) $\sqrt{Dd}$ 2) $\frac{2Dd}{D+d}$ 3) $\frac{D+d}{2}$ 4) $\frac{Dd}{D+d}$

44. A boat floating in fresh water (density 1000kg/m^3) displaces water weighing 35.2 kN. The change in volume of the displaced water if it were floating in sea water of density 1.1 x 10^3 kg/m^3 will be (take g = 10m/s^2)

1) 32 m^3 2) 35.2m^3 3) 3.2 m^3 4) 0.32 m^3

45. An iceberg is floating partly immersed in seawater of density 1.03 gm/cm^3 .If the density of ice is 0.92 gm/cm^2, then the fraction of total volume of the iceberg above the level of seawater is

1) 89% 2) 11% 3) 1% 4) 34%

46. A block of wood floats in water with (4/5)th of its volume submerged .In an oil, it floats with (9/10)th of its volume submerged .The ratio of the density of oil and water is

1) 8/9 2) 9/8 3) 19/25 4) 25/18

TERMINAL VELOCITY

47. Twenty seven rain drops of same diameter fall through air with terminal velocity 'V'. If they coalesce forming a single drop, then the terminal velocity of the resultant drop is

1. V 2. 3 V 3. 9 V 4. $\frac{V}{9}$

48. A metal sphere of diameter 7 cm falls through a liquid of coefficient of viscosity 0.8 pas. When its velocity is 20 cms^{-1} the viscous force acting onit is nearly ----N

1. 0.11 2. 0.22 3. 0.3 4. 0.01

49. A metal ball of radius 1 mm and density 10^{4}kg m^{-3}. falls freely in air through a height 'h' before falling in a tank full of water. If on falling in water its velocity remains unchanged, then the value of h will be (Coefficient of viscosity of water = 10^{-3} pas and g = 10ms^{-2})

1. 10m 2. 15 m 3. 25 m 4. 20 m

50. An air bubble of radius 5 x 10^{-4}m rises in a liquid of viscosity 0.1 Pas (g=10ms^{-2}) and density 900kgm^{-3}. The terminal velocity of the bubble is

1. 0.005ms^{-1} 2. 0.01ms^{-1} 3. 0.5ms^{-1} 4. 0.4ms^{-1}

51. One spherical ball of radius R, density d released in a liquid of density d/2 attains a terminal velocity V. Another ball of radius 2R and density 1.5d, released in the liquid will attain a terminal velocity

1. 2V 2. 4V 3. 6V 4. 8V

52. Two equal drops of water are falling through air with a steady velocity of 10cms^{-1}. If the drops recombine to form a single drop then the terminal velocity is

1) $2^{\frac{2}{3}} \times 5cms^{-1}$ 2) $2^{\frac{2}{3}} \times 10cms^{-1}$
3) $2^{\frac{2}{3}} \times 15cms^{-1}$ 4) $2^{\frac{2}{3}} \times 4cms^{-1}$

53. The mass of a lead ball is M. It falls down in a viscous liquid with terminal velocity V. The terminal velocity of another lead ball of mass 8M in the same liquid will be

1) 64V 2) 4V 3) 8V 4) V

54. When a solid ball of volume V is falling through a viscous liquid, a viscous force F acts on it. If another ball of volume 2V of the same material is falling through the same liquid then the viscous force experienced by it will be (when both fall with terminal velocities).

1) 2F 2) $\frac{F}{2}$ 3) 2F 4) $\frac{F}{4}$

KEY

1.3	2.4	3.4	4.3	5.3	6.2
7.4	8.1	9.1	10.4	11.2	12.2
13.3	14.4	15.4	16.2	17.2	18.3
19.2	20.1	21.4	22.1	23.2	24.3
25.2	26.3	27.3	28.3	29.4	30.4
31.1	32.1	33.2	34.3	35.1	36.3
37.2	38.3	39.3	40.3	41.2	42.3
43.3	44.4	45.2	46.1	47.3	48.1
49.4	50.1	51.4	52.2	53.3	54.3

LEVEL - III

1. Water is flowing continuously from a tap having a bore of internal diameter 8×10^{-3} m. The diameter of the water stream at a distance 2m below the tap is (Assume that the velocity of the water as it leaves the tap is 0.4 ms^{-1})
   1. 7×10^{-3} m 2. 2×10^{-3} m
   3. 4.55×10^{-3} m 4. 16×10^{-3} m
2. Water flows through a pipe of radius 1.0 cm . The viscosity of water is 10^{-3} kg m^{-1}s^{-1}. If the velocity of the flow at the centre is 10 cm s^{-1}, the pressure drop along a 2m section of the pipe due to viscosity is : (in Nm^{-2})
   1. 0.008 2. 0.08 3. 0.8 4. 8
3. Air is streaming past a horizontal aeroplane wing such that its speed is 120 ms^{-1} at the upper surface and 90 ms^{-1} at the lower surface. If the wing is 10m long and 2m wide and density of air is 1.3 kgm^{-3}, the gross lift on it will be (in newton)
   1. 81.9 2. 8.19 3. 4.095×10^{4} 4. 8.19×10^{4}
4. A liquid is kept in a cylindrical vessel which is rotated along its axis. The liquid raises at the sides. If the radius of the vessel is 0.05 m and the speed of rotation is 2 revolutions per second, the difference in the height of the liquid at the centre of the vessel and sides is about
   1. 0.2 m 2. 0.01m 3. 0.03 m 4. 0
5. A vessel has water to a height of 40 cm. It has three horizontal tubes of same diameter each of length 15cm coming out at heights 10cm, 15cm, 20 cm. The length of a single tube of same diameter as that of the three tubes which can replace them when placed horizontally at the bottom of the vessel is :
   1. 45 cm 2. 5 cm 3. 8 cm 4. 16 cm
6. In giving a patient blood transfusion, a needle of length 3.14 cm and internal diameter 0.4 mm is used. If 4c.c. of blood passes through the needle in 1minute the height of the blood level in the bottle above the needle is approximately.
   [density of blood = 1.02 gm/cc; Viscosity of blood = 0.02 poise ; g = 10ms^{-2}]
   1. 85 cm 2. 75 cm 3. 65 cm 4. 50 cm
7. Two capillary tubes of same radius but lengths l and 2l are connected in series to the bottom of a vessel containing water. The length of a single tube of same radius that can replace the two tubes so that pressure difference across the single tube is equal to total pressure difference across the combination is
   1. 3l 2. $\frac{2l}{3}$ 3. 1.5l 4. $\frac{l}{3}$
8. In the above problem, if the same tubes are connected side by side (parallel) then the length of the single tube of same radius that can replace the two tubes so that the rate of volume flow through it is equal to total rate of volume flow through the two tubes is
   1. 3l 2. $\frac{2l}{3}$ 3. 1.5l 4. $\frac{l}{3}$

KEY

1. 2	2. 4	3. 4	4. 1	5. 3
6. 3	7. 1	8. 2		

HINTS

1. $v_2=\sqrt{v_1^2+2gh}$

   $d_1^2.v_1=d_2^2.v_2$ (d_1, d_2 are diameters)

   $d_2=d_1\times\sqrt{\frac{v_1}{v_2}}$

2. $V=\frac{P}{4\eta l}\left[r^2-x^2\right]$ and x = 0

3. Buoyant Force = pressure diff x Area

   $= (P_2-P_1)A=\frac{\rho}{2}\left(v_2^2-v_1^2\right)\times A$

4. $P=\frac{1}{2}\rho v^2;\ p=h\rho g$

   $\therefore h\rho g=\frac{1}{2}\rho v^2 \Rightarrow h=\frac{v^2}{2}=\frac{r^2\omega^2}{2}$

5. h is total height of water. $h_1, h_2\ h_3$ are the heights at which tubes are fitted

   $Q_1=\frac{\pi(h-h_1)dgr^4}{8\eta l}, Q_2=\frac{\pi(h-h_2)dgr^4}{8\eta l}$

   $Q_3=\frac{\pi(h-h_3)dgr^4}{8\eta l}$ and $Q=Q_1+Q_2+Q_3$

   with $Q=\frac{\pi hdgr^4}{8\eta l}$

6. $Q = \dfrac{\pi hdgr^4}{8\eta l}$ and $Q = \dfrac{\text{volume}}{\text{time}}$

7. $R = \dfrac{8l\eta}{\pi r^4} \Rightarrow R\alpha l$

When capillaries are connected in series,

$R = R_1 + R_2 \Rightarrow L_R = L_1 + L_2$

8. $L_R = \dfrac{L_1 L_2}{L_1 + L_2}$

NEW PATTERN QUESTIONS

1. Assertion : Water flows faster than honey.
Reason: The coefficient of viscosity of water is less than honey.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2) Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

2. Assertion: The viscosity of liquid decreases with rise of temperature.
Reason: Viscosity of a liquid is the property of the liquid by virtue of which it opposes the relative motion amongst its different layers.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2) Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

3. Assertion: Sudden fall of pressure at a place indicates storm
Reason: Air flows from higher pressure to lower pressure.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

4. Assertion: Aero planes are made to run on the runway before take off, so that they acquire the necessary lift.
Reason: According to Bernoulli's theorem, as velocity increases pressure decreases and vice versa.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

5. Assertion: Machine parts are jammed in winter
Reason: The viscosity of lubricant used in machine parts increase at low temperature.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

6. Assertion: An object falling through a viscous medium eventually attains terminal velocity
Reason: All the rain drops hit the surface of the earth with the same constant velocity
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

7. Assertion: For the flow to be streamline; value of critical velocity should be as low as possible
Reason: Once the actual velocity of flow of liquid becomes greater than the critical velocity; the flow becomes turbulent.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

8. Assertion: A raindrop after falling through some height attains a constant velocity
Reason: At constant velocity; the viscous drag is equal to its weight.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

9. Assertion: The upper surface of the wings of an aero plane is made convex
Reason: The air current at the top will have greater velocity and thus pressure at the bottom will be greater than at the top
1) Both assertion and reason are true and reason is correct explanation of assertion.
2)Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

10. Assertion: To float; a body must displace liquid whose weight is equal to the actual weight.
Reason: The body will experience no net downward force in that case.
1) Both assertion and reason are true and reason is correct explanation of assertion.
2) Both assertion and reason are true but reason is not the correct explanation of assertion.
3) Assertion is true but reason is false.
4) Both assertion and reason are false.

11. Read the following statements and pick the correct choice
Statement A: With increase in temperature, viscosity of a gas increases and that of a liquid decreases.
Statement B: If the density of a small sphere is equal to the density of the liquid in which it is dropped, then the terminal velocity of the sphere will be zero.
1) Both A and B are true 2) Both A and B are false
3) A is true and B is false 4) B is true but A is false.

12. Viscous force a is similar to friction in solids , but viscous force
a. is independent of area but friction depends on area
b. is temperature dependent while friction force between solids depends upon normal reaction
c. is velocity dependent while friction is velocity independent
1) a,b, c are correct 2) a,c are correct
3) b,c are correct 4) a, b are correct

13. In the case of motion of a fluid in a tube where area of cross section is maximum
a) velocity is maximum b) pressure is maximum
c) velocity is minimum d) pressure is minimum
1) b,c are correct 2) a, d are correct
3) a,b,c are correct 4) c, d are correct

14. When an air bubble moves up from the bottom of a lake
a)velocity decreases and becomes zero
b) acceleration increases and becomes zero
c) velocity increases and becomes constant
d) acceleration decreases and becomes zero
1) a,d are correct 2) a, b are correct
3) c,d are correct 4) c is correct

15.

Section-A	Section-B
a) Equation of continuity	e) less than critical velocity
b) Bernoulli's theorem	f) Formation of eddies and vortices
c) Turbulent flow	g) Law of conservation of mass
d) Stream line flow	h) Law of conservation of energy

1) a- h; b-f; c-e; d-g
2) a-e; b-h; c-f; d-g
3) a-f; b-f; c-e; d-h
4) a-g; b-h; c-f; d-e

16.

Section-A	Section-B
a) Incompressible liquid	e) Density constant
b) Turbulent flow	f) Stream lines
c) Tube of flow	g) Constant
d) Fluid flux rate in laminar flow	h) Reynolds's no>2000

1) a-f; b-e; c-g; d-h
2) a-e; b-h; c-f; d-g
3) a-g; b-f; c-e; d-h
4) a-h; b-g; c-e; d-f

17. Match of the physical quantities given here under having same units and dimensions

Section-A	Section-B
a) Kinematic viscosity	e) $\frac{1}{2}\rho(v_2^2 - v_1^2)A$
b) Dynamic lift	f) $\frac{\eta}{\rho}$
c) Bernoulli's theorem	g) a v = constant
d) Equation of continuity	h) $p + \frac{1}{2}\rho v^2 + \rho gh =$ constant

1) a-f; b-e; c-h; d-g 2) a-f; b-e; c-g; d-h
3) a-g; b-f; c-e; d-h 4) a-h; b-g; c-f; d-e

Key

1.1	2.2	3.1	4.1	5.1	6.3
7.1	8.3	9.1	10.1.	11.1	12.3
13.1	14.3	15.4	16.2	17.1	

PREVIOUS EAMCET QUESTIONS

1. When temperature is increased: **(MED 2004)**
a) viscosity of the gas increases
b) viscosity of the gas decreases
c) viscosity of the liquid decreases
d) viscosity of the liquid increases
1) a and c are true 2) b and c are true
3) b and d are true 4) a and d are true

2. A tank full of water has a small hole at the bottom. If one-fourth of the tank is emptied in t_1 seconds and the remaining three-fourths of the tank is emptied in t_2 seconds. Then the ratio $\frac{t_1}{t_2}$ is
1) $\sqrt{3}$ 2) $\sqrt{2}$ 3) $\frac{1}{\sqrt{2}}$ 4) $\frac{1}{\sqrt{3}}$

(2004M)

3. Water in a river 20m deep is flowing at a speed of $10ms^{-1}$. The shearing stress between the horizontal layers of water in the river in Nm^{-2} is : (coefficient of viscosity of water = 10^{-3} SI units)

(2004E)

1) 1×10^{-2} 2) 0.5×10^{-2} 3) 1×10^{-3} 4) 0.5×10^{-3}

4. There are two holes one each along the opposite sides of a wide rectangular tank. The cross section of each hole is $0.01m^2$ and the vertical distance between the holes is one meter. The tank is filled with water. The net force on the tank in Newton when water flows out of the holes is: (Density of water $1000kg/m^3$) **(2004 E)**

1) 100 2) 200 3) 300 4) 400

5. A square plate of 0.1 metre side moves parallel to a second plate with a velocity of 0.1 m/s, both plates being immersed in water. If the viscous force is 0.002 newton and the coefficient of viscosity is 0.01 poise, distance between the plates in metre is **(MED 2003)**

1)0.1 2)0.05 3)0.005 4)0.0005

6. A large tank filled with water to a height 'h' is to be emptied through a small hole at the bottom.The ratio of times taken for the level of water to fall from h to h/2 and from h/2 to zero is **(2003M)**

1) $\sqrt{2}$ 2) $\frac{1}{\sqrt{2}}$ 3) $\sqrt{2}-1$ 4) $\frac{1}{\sqrt{2}-1}$

7. A water barrel having water up to depth 'd' is placed on a table of height 'h'. A small hole is made on the wall of the barrel at its bottom. If the stream of water coming out of the hole falls on the ground at a horizontal distance 'R' from the barrel, then the value of 'd' is **(2002E)**

1. $\frac{4h}{R^2}$ 2. $4hR^2$ 3. $\frac{R^2}{4h}$ 4. $\frac{h}{4R^2}$

8. Tanks A and B open at the top contain two different liquids upto certain height in them. A hole is made on the wall of each tank at a depth 'h' from the surface of the liquid. The area of the hole in 'A' is twice that of in B. If the liquid mass flux through each hole is equal, then the ratio of the densities of the liquids respectively is **(2002E)**

1. $\frac{2}{1}$ 2. $\frac{3}{2}$ 3. $\frac{2}{3}$ 4. $\frac{1}{2}$

9. Water is conveyed through a uniform tube of 8 cm in diameter and 3140m in length at the rate of $2\times10^{-3}\,m^3$ per second. The pressure required to maintain the flow is (viscosity of water = 10^{-3} S.I. units) **(2001E)**

1. 6.25 Nm^{-2} 2. 0.625 Nm^{-2}
3. 0.0625 Nm^{-2} 4. 0.00625 Nm^{-2}

10. A tank with vertical walls is mounted so that its base is at a height H above the horizontal ground. The tank is filled with water to a depth 'h' . A hole is punched in the side wall of the tank at a depth 'x' below the water surface. To have maximum range of the emerging stream, the value of x is **(2001E)**

1. $\frac{H+h}{4}$ 2. $\frac{H+h}{2}$ 3. $\frac{H+h}{3}$ 4. $\frac{3(H+h)}{4}$

11. A solid rubber ball of density 'd' and radius 'R' falls vertically through air. Assume that the air resistance acting on the ball is F = KRV where K is constant and V is its velocity. Because of this air resistance the ball attains a constant velocity called terminal velocity V_T after some time. Then V_T **(2001E)**

1. $\frac{4\pi R^2dg}{3K}$ 2. $\frac{3K}{4\pi R^2dg}$ 3. $\frac{4}{3}\frac{\pi r^3dg}{K}$ 4. $\pi rdgk$

12. An aeroplane of mass 3×10^4 kg and total wing area $120m^2$ is in a level flight at same height. The difference in pressure between the upper and lower surface of its wings in Kilo Pascal is ($g = 10\ ms^{-2}$) **(2002M)**

1. 2.5 2. 5.0 3. 10.0 4. 12.5

13. In a plant, sucrose solution of coefficient of viscosity $0.0015\ N.m^{-2}$ is driven at a velocity of $10^{-3}\ m\,s^{-1}$ through xylem vessels of radius 2 μm and length 5 μm. The hydrostatic pressure difference across the length of xylem vessels in Nm^{-2} is : **(2002M)**

1. 5 2. 8 3. 10 4. 15

14. Consider the following two statements A and B and identify the correct choice in the following.
A : Viscosity of liquids decrease with decrease of temperature
B: Surface tension of liquids decreases with increase of temperature **(2001M)**

1. Both A and B are true
2. A is true but B is false
3. A is false but B is true
4. Both A and B are false

15. A liquid is flowing in a horizontal uniform capillary tube under a constant pressure difference P. The value of pressure for which the rate of flow of the liquid is doubled when the radius and length are doubled is **(2001M)**

1. P 2. $\frac{3P}{4}$ 3. $\frac{P}{2}$ 4. $\frac{P}{4}$

16. An iron sphere of mass 20x 10^{-3} kg falls through aviscous liquid with terminal velocity 0.5ms^{-1}. The terminal velocity (in ms^{-1}) of another iron sphere of mass 54 x 10^{-2}kg is: **(2005E)**

1) 4.5 2) 3.5 3) 2.5 4) 1.5

17. Two rain drops reach the earth with their terminal velocities in the ratio 4:9. The ratio of their radii is: **(2005M)**

1) 4: 9 2) 2 : 3 3) 3 : 2 4) 9: 4

Key

1.1	2.4	3.4	4.2	5.4
6.3	7.3	8.4	9.3	10.2
11.1	12.1	13.4	14.3	15.4
16.1	17.2			

QUESTIONS FROM OTHER COMPETITIVE EXAMINATIONS

1. Water is flowing through a tube of non-uniform cross section. If the radius of the tube at the entrance and the exit is in the ratio 3 :2, then ratio of velocity of water entering and leaving the tube is (PET - 91)

1. 8:27 2. 4 :9 3. 1:1 4. 9:4

2. Two drops of small radius are falling in air with constant velocity 5 cms^{-1}. If they coalesce, then the terminal velocity will be (PMT - 91)

1. 10 cms^{-1} 2. 2.5 cm s^{-1}

3. 5 x $\sqrt[3]{4}$ cms^{-1} 4. 5.$\sqrt{2}$ cm s^{-1}

3. The level of water in a tank is 5m high. A hole of area 1 cm^2 is made at the bottom of the tank. The rate of leakage of water from the hole in m^3/s is (g= 10 ms^{-2}) (PMT - 95)

1. 10^{-3} 2. 10^{-4} 3. 10 4. 10^{-2}

4. A metal ball of radius 2mm and density 10.5$gmcm^{-3}$ is dropped in glycerine of coefficient of viscosity 9.8 poise and density 1.5 gm cm^{-3}. The terminal velocity of the ball in cm s^{-1} is (PET-93)

1. 2 2. 4 3. 6 4. 8

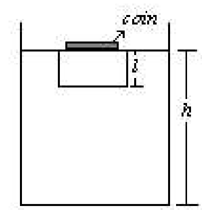
5. Under a constant pressure head, the rate of orderly volume flow of liquid through a capillary tube is Q. If the length of the tube is doubled and the diameter of the bore is halved, then the rate of flow would become (AIIMS)

1. $\frac{Q}{4}$ 2. $\frac{Q}{16}$ 3. $\frac{Q}{32}$ 4. $\frac{Q}{8}$

6. 16 c.c.of water flows per second through a capillary tube of radius a cm and of length l cm when connected to a pressure head h cm of water. If a tube of same length and radius $\frac{a}{2}$ cm is connected to the same pressure head, the quantity of water flowing through the tube per second will be (BHU-93)

1. 16 c.c 2. 4 c.c 3. 1 c.c 4. 8 c.c

7. A wooden block with a coin placed on its top floats in water as shown. After some time the coin falls into water. Then



[IIT 2002]

1) l decreases and h increases

2) l increases and h decreases

3) both l and h increase 4) both l and h decrease

8. Scent sprayer is based on [AIIMS 2002]

1) Charles law 2) Boyle's law

3) Archimedes principle 4) Bernoulli's theorem

9. A cylinder of height 20m is completely filled with water. The velocity of efflux of water (in ms^{-1}) through a small hole on the side wall of the cylinder near its bottom is [AIEEE 2002]

1) 10 ms^{-1} 2) 20 ms^{-1} 3) 25.5 ms^{-1} 4) 5 ms^{-1}

10. The terminal velocity of a small ball falling in a viscous liquid depends upon

i) its mass m ii) its radius r

iii) the coefficient of viscosity of the liquid η and

iv) acceleration due to gravity. Which of the following relations is dimensionally true for the terminal velocity. [MP PMT 2001]

1) $V = \frac{Kmg}{\eta r}$ 2) $V = \frac{Kmgr}{\eta}$

3) $V = \frac{Kmg\eta}{r}$ 4) $V = \frac{Kr\eta}{mg}$

11. Water flows through a non-uniform tube of area of cross section of whose parts A,B,C are 25, 5 and 35 cm^2 respectively. Which part has the highest velocity?
1) A 2) B 3) C
4) All have same velocity

12. Two balls of same density falls in a viscous medium. The radius of first ball being double than the radius of second ball, then how many times is the sedimentation velocity of second ball to that of first ball [IIT 2001]
1) 1 2) 2 3) 4 4) ¼

13. A wind - powered generator converts wind energy into electrical energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed V, the electrical power output will be proportional to
1) V 2) V^2 3) V^3 4) V^4

14. Water from a tap emerges vertically down with an initial speed of $1.0ms^{-1}$. The cross sectional area of tap is $10cm^2$. Assume that the pressure is constant through out the stream of water, and that the flow is steady, the cross sectional area of the steam 0.15m below the tap is [UP SET 2000]
1) $5.0 \times 10^{-4}m^2$ 2) $1.0 \times 10^{-5}m^2$
3) $5.0 \times 10^{-5}m^2$ 4) $2.0 \times 10^{-5}m^2$

15. A drop of liquid having radius 2mm has a terminal velocity $20cms^{-1}$, the terminal velocity of a drop 1 mm radius will be [AFMC 2000]
1) 40 cms^{-1} 2) 20 cms^{-1}
3) 10 cms^{-1} 4) 5 cms^{-1}

16. 16 cm^3 of water flows per second through a capillary tube of radius a cm and of length 1 cm when connected to a pressure head of h cm of water. Another tube of the same length and radius a/2 cm is connected to the same pressure head the quantity of water flowing through the tube per second will be [CPMT 98]
1) 16 cm^3 2) 4 cm^3 3) 1 cm^3 4) 8 cm^3

17. An air bubble of radius 1 mm moves up with uniform velocity of $0.109ms^{-1}$ in a liquid column of density $14.7 \times 10^3 kg/m^3$, then coefficient of viscosity will be ($g = 10ms^{-2}$) [Raj PET 1997]
1) 1.3 Pa s 2) 300 Pa s
3) 15 Pa s 4) 150 Pa s

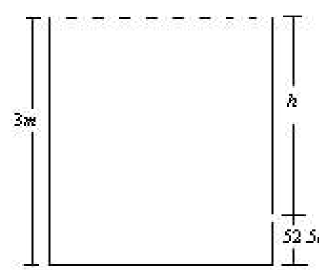
18. A large open top container of negligible mass and uniform cross sectional area "A" has a small hole of cross sectional area "a" in its side wall near the bottom. The container is kept over a smooth horizontal floor and contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing through the hole A, the acceleration of the container will be [IIT 1997]
1) $\frac{2ag}{A}$ 2) $\frac{ag}{A}$ 3) $\frac{2Ag}{a}$ 4) $\frac{Ag}{a}$

19. A small steel ball is dropped from a height of 1.5m into a glycerin jar. The ball just reaches the bottom of the jar 1.5 sec after it was dropped. The height of the glycerin in the jar, if the retardation is $2.66ms^{-2}$, is about [AMU 95]
1) 7.0 m 2) 7.5m 3) 5.5m 4) 3.2m

20. A horizontal pipe line carries water in a streamline flow. At a point along the pipe where cross sectional area is $10cm^2$, the water velocity is $1ms^{-1}$ and the pressure is 2000Pa. The pressure of water at another point where the cross sectional area is $5cm^2$ is [IIT 94]
1) 1000Pa 2) 1500Pa 3) 3500 Pa 4) 1025 Pa

21. A bird of mass 1.23kg is able to hover by imparting a downward velocity of 10 m/s uniformly to air of density 'p' kg/m^3 over an effective area $0.1m^2$. If the acceleration due to gravity is $10m/s^2$, then the magnitude of 'p' in kg/km^3 (MED 2003)
1)0.0123 2)0.123 3)1.23 4)1.32

22. Ratio of area of hole to beaker is 0.1. Height of liquid in beaker is 3m, and hole is at the height of 52.5 cm from the bottom of the beaker, find the square of the velocity of liquid coming out from the hole (take $g = 10m/s^2$) (IIT 2005)



1) $50(m/s)^2$ 2) $50.5 (m/s)^2$
3) $51(m/s)^2$ 4) $42(m/s)^2$

KEY

1.1	2.3	3.1	4.4	5.3
6.3	7.2	8.4	9.2	10.1
11.2	12.4	13.3	14.3	15.4
16.3	17.1	18.1	19.3	20.2
21.3	22.1			