Question Bank

CHAPTER 10-MECHANICAL PROPERTIES OF FLUIDS

Each question scores One

1	The hydraulic lift is based on which of the following a) Bernoulli's principle b) Pascal's Law c) Archimedes' principle d) Boyle's law Ans: Pascal's Law
2	Pick the odd one out from the following a) Atomiser b) Hydraulic Lift c) Venturimeter d) Aerofoil Ans: Hydraulic Lift
3	SI Unit of pressure is.... Ans: N/m2 or Pascal.
4	Dimensional formula of pressure is..... Ans: $ML^{-1}T^{-2}$
5	Pressure is a.... quantity? Ans. Scalar (Tensor)
6	Pascal's law is applicable to..... Ans. Continuous liquid at rest.
7	Hydraulic lift is based on..... Ans: Pascal's law.
8	Equation of continuity is in accordance with..... Ans: Law of conservation of mass.
9	Bernoulli's theorem is in accordance with..... Ans: Law of conservation of energy.
10	Bernoulli's theorem is applicable to..... Ans: Stream line flow.
11	Velocity of efflux is based on.....

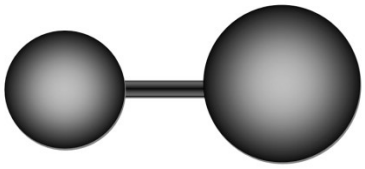
	Ans: Bernoulli's theorem.
12	Spinning of balls(Swing) can be explained using..... Ans: Bernoulli's theorem
13	_____ gives an idea about the pressure in a static fluid. a) Newtons Law b) Charles law c) Bernoulli principle d) Pascal's law. Ans: Pascal's law.
14	All fluids exert..... a) pressure in the direction of flow only b) pressure in the direction of force of gravity c) equal pressure in all directions d) equal pressure only in x, y and z planes Ans: equal pressure in all directions
15	The aircraft fly based on which principle _____ a) Newton's third law b) Conservation of mass c) Bernoulli's principle d) Gravity Ans : Bernoulli's principle
16	Bernoulli's equation is applicable only for _____ a) Irrotational flow b) Viscous flow c) Inviscid, incompressible flow d) Compressible flow Ans: Inviscid, incompressible flow
17	Bernoulli's principle is derived from which of the following? a) Conservation of mass b) Conservation of energy c) Newton's law of motion d) Conservation of momentum Ans : Conservation of energy
18	The SI unit of hydro-static pressure is : Ans: Pascal(Pa)
19	Fill in the blanks. a) Venturimeter : Bernoulli's theorem b) Hydraulic lift : ..... c)

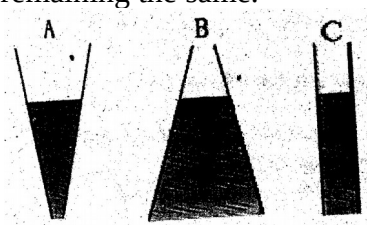
	Ans: Pascal's law.
20	Normal force acting on a surface is called..... Ans: Thrust.
21	The device used to measure atmospheric pressure is..... Ans: Barometer
22	Liquids are preferred in hydraulic lifts than gases. Why ? Ans: Gases are compressible than liquids.
23 d)	Is Bernoulli's Theorem valid for viscous liquids? Ans: No

Each question scores Two

1	Define Pressure? Ans: Normal force acting per unit area is called pressure. P= F/A Unit : SI unit for pressure is Pascal (Pa) Other Units N/m^2, or $kg \cdot m^{-1} \cdot s^{-2}$
2	When air is blown in between the two light weight balls which are hanging sideways will they attract or repel? Explain Why Ans: When air is blown in between two balls suspended close to each other with high speed, a low pressure is created between the balls which is much less than the atmospheric pressure beyond the balls. Due to this, balls are attracted towards each other. This is according to Bernoulli's theorem.
3	We can cut an apple easily with a sharp knife as compared to with a blunt knife. Explain why? Ans: The area of a sharp edge is much less than the area of a blunt edge. For the same total force, the effective force per unit area (or pressure) is more for the sharp edge than the blunt one. Hence a sharp knife cuts easily than a blunt knife.
4	According to Bernoulli's theorem, the pressure of water in a horizontal pipe of uniform diameter should remain constant. But actually it goes on decreasing with the increase in length of the pipe. Why? Ans: Bernoulli's theorem is valid only for non- viscous liquids. But water is a viscous liquid. A part of the pressure energy of water is used in doing work against the viscous force. So the pressure of water decreases.
5	Is Bernoulli's theorem valid for viscous liquid? Ans: No, it should be modified to take into account the work done against viscous drag.
6	Why bullets are given cylindrical shape? Answer:

	The Magnus effect is absent if the spinning cylinder is moving linearly in the direction parallel to spin axis. That is why the bullets are made cylindrical instead of spherical. They do not deviate from the linear path.
7	The areas of the pistons in a hydraulic machine are 5cm 2 and 625cm 2 . What force on the smaller piston will support a load of 1250N on the larger piston? Ans: $F_1 = 1250N$ $A_1 = 625cm^2$ $F_2 = xN$ $A_2 = 5cm^2$ Since pressure is constant. $\frac{F_1}{A_1}=\frac{F_2}{A_2}$ $\frac{1250}{625}=\frac{x}{5}$ x= 10N
8	State whether true or false:The deeper an underwater swimmer goes, the more strongly the water pushes on his body and the greater is the pressure that he experiences. Explain Why Ans: True When the swimmer wants to dive deeper, he will have to hold his breadth. Water is heavy and as he swims deeper, the water pressure increases and presses on his body. The air in his lungs are compressible so as he swims deeper the volume of his lungs decreases. Hence, the statement is true
9	In hydraulic machine, the two pistons are of area of cross section in the ratio 1:10. What force is needed on the narrow piston to overcome a force of 100N on the wider piston? Ans: $F_1 = 100N$ $A_1 = 10m^2$ $F_2 = xN$ $A_2 = 1m^2$ Since pressure = constant hence, $\frac{F_1}{A_1}=\frac{F_2}{A_2}$ $\frac{100}{10}=\frac{x}{1}$ x= 10N
10	A hydraulic lift at a service station can lift cars with a mass of 3500 kg . The area of cross section of the piston carrying the load is 500 cm^2 . What pressure does the smaller piston experience? g = 9.8m/s^2 Ans: Pressure $\frac{Force}{Area}=\frac{3500\times 9.8}{500\times 10^{-4}}=6.86\times 10^5\ N/m^2$
11	To keep a piece of paper horizontal, you should blow over, not under it. Why? Ans:When we blow over a piece of paper the velocity of air above the paper increases so in accordance with bernoulli's theorem($P+\rho gh+1/2\rho\upsilon^{2)}$ the pressure of air decreases above the paper. Due to the pressure difference of air between below and above the paper a lifting force act on paper and hence it remain horizontal
12	Define equation of continuity? Ans: Amount of liquid entering to a pipe in unit time is equal to the amount of liquid leaving in unit time.

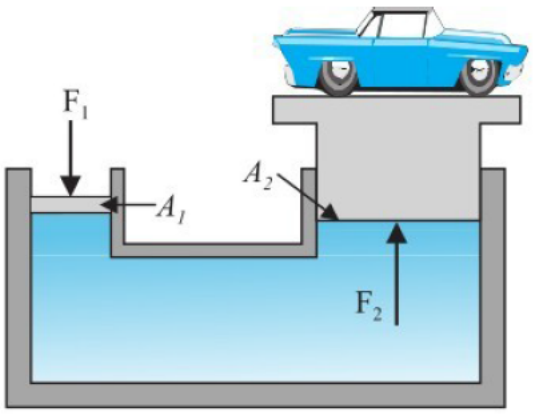
13	Define Bernoulli's theorem? Ans: In a stream line flow total energy of a fluid remains constant.
14	Air streams horizontally pass an air plane . The speed over the top surface is 60 m/s and that under bottom surface is 45 m/s. What is the difference in pressure ? (Density of air = 1.293 kg /m^3) Ans: $P_1 / \rho + ½ v_1^2 = P_2 / \rho + ½ v_2^2$, $P_2 – P_1 = ½ \rho (v_1^2 – v_2^2) = 1018$ N /m^2
15	Two spherical shaped balloons are inter connected as shown in the figure using a tube.  Here what happens to the balloons ? Explain why ? (i)Both becomes same size (ii)Size of bigger balloon increases (iii)Size of smaller balloon increases. Ans: Size of bigger balloon increases Excess pressure inside the smaller balloon will be greater than that in the bigger balloon. Air flows from higher pressure region to lower pressure region.
16	A hydraulic auto mobile lift is designed to lift cars with a maximum mass of 3000 kg. The area of cross section of the piston carrying the load is 425 cm^2. What is the maximum pressure that the smaller piston have to bear ? Ans: $P = F / A = mg / A(\text{in } m^2) = 7.1 \times 10^5$ N / m^2
17	Why firefighters have a jet attached to the head of their water pipes? Ans: This is done to increase the velocity of water flowing out of the pipe.
18	Why the air planes and cars are given a streamlined shape? Ans: This is done to reduce the backward drag of the atmosphere.
19	People living in houses far removed from a municipal water tank often find it difficult to get water on the top floor even if it is situated lower than the level of water tank. Why? Ans: This is because there is a loss of pressure when water is flowing
20	Why flags flutter on a windy day? Ans: Velocity increases and pressure decreases on a windy day.
21	What is the effect on the equilibrium of a physical balance when air is blown below one pan?

	An. Velocity increases and thus pressure will decrease below that pan, hence it will go down
22	Why are sleepers used below the rails? Explain. Ans: When sleepers are placed below the rails, the area of the cross section is increased. We know that P = F/A, so when the train runs on the rails, the pressure exerted on the ground due to the weight of the train is small because of a large area of cross-section of the sleeper. Hence the ground will not yield under the weight of the train.
23 e)	A light ball can remain suspended in a vertical jet of water flow? Ans: The region where the ball and the vertical jet of water are in contact is a region of low pressure because of higher velocity. The pressure on the other side of the ball is larger. Due, to the pressure difference, the ball remains suspended.
24	An ideal fluid flows through a pipe of circular cross-section made of two sections with diameters 2.5 cm and 3.75 cm. The ratio of the velocities in the two pipes is Ans: 9:4 $a_1 v_1 = a_2 v_2$ $\frac{v_1}{v_2} = \frac{a_2}{a_1}$ $\frac{v_1}{v_2} = \frac{(d_2)^2}{(d_1)^2}$ putting values, $\frac{v_1}{v_2} = \frac{(3.75)^2}{(2.5)^2} = \frac{9}{4}$
25	Three vessels of different shapes are filled with water to the same height ‘h’ and their bottom parts are connected to manometers measures the same pressure. The water levels in all the vessels remaining the same.  Identity the above phenomenon. Ans**:** Hydrostatic paradox
26	Blood pressure in humans is greater at the feet than at the brain. Explain why. Ans: According to pressure depth relationship P = hρg, h–depth, ρ–density and g–acceleration due to gravity. As per the above equation blood pressure in humans will be greater at the feet than at the brain.
27	Why does the small water drop acquire a spherical shape?

	Ans: Due to surface tension. (For a given volume, surface area is minimum for sphere. Surface tension is the tendency of free surface to contract so as to minimize the surface area)
28	Surface tension changes with temperature. a) Hot soup is tastier than cold one. Why? Ans: Hot soup is more tasteful than the cold one because the surface tension of the hot soup is less than that of the cold and so spreads over a larger area of the tongue. b) Washing of cloths is easier in warm water than cold water. Why? Ans: Warm water has lower surface tension comparing with cold water and can wet the dirty clothes in better way and achieves greater cleaning action.

Each question scores Three

1	Bernoulli?s theorem holds for incompressible, non-viscous fluids. How is this relationship changed when the viscosity of the fluid is not negligible? Answer: If the viscosity of the fluid is not negligible, a part of the mechanical energy of the fluid is spent in doing work against forces of viscosity. So the total energy:$P+\rho gh+1/2\rho\upsilon^2$of the fluid goes on decreasing along the direction of flow of the fluid.
2	In case of an emergency, a vacuum brake is used to stop the train. How does this brake work? Answer: Steam at high pressure is allowed to enter the cylinder of the vacuum brake. Due to high velocity, the pressure decreases in accordance with Bernoulli's principle. The reduction of pressure lifts up the piston. This in turn lifts up the brake.
3	The accumulation of snow on the aeroplane may reduce the lift. Explain. Answer: Due to the accumulation of snow on the wings of the aeroplane, the shape of the wings no longer remains that of the aerofoil. This reduces the path difference and hence the velocity difference between the layer of air on the two sides of the wings. Hence the pressure difference on the two sides of the wings is reduced. This reduces the uplift on the aeroplane.
4	The windows of older trains sometimes break when a high-speed train passes by on the next track. What physics concept underlies this observation? Answer When a high-speed train passes the other train, the air in the track will be pushed off with a greater speed, creating a low-pressure region near the other train. The old trains will have long-used windows, and hence its quality will be less. The high-pressure region inside the train pushes the air to a low-pressure region through the aged windows. This results in the damage of the windows.
5	Why it is dangerous to stand near the edge of the platform when a fast train is crossing it? Answer: When a fast train crosses the platform, the air dragged along with the train also moves with a high velocity. In accordance with Bernoulli's equation, the pressure in the region of high velocity gets decreased. If a person stands near the edge of the platform he may be pushed towards the train due to high pressures outside.

6	Why do the load carrying heavy vehicles have large number of wheels? Ans: We know, Pressure = Force/Area So, greater the area of contact between two surfaces, lesser will be the pressure. So, the load carrying heavy vehicles have large number of wheels so that the pressure on the road is reduced due to larger contact area. Also, using large number of wheels ensures that the force due to the load is shared among the tyres and no single tyre is under stress.
7	A hydraulic machine exerts a force of 900N on a piston of diameter 1.80cm .The output force is exerted on a piston of diameter 36cm . What will be the output force? Ans: $F_1 = 900N$ $F_2 = x\ N$ $r_1 = 0.9cm$ $r_2 = 18cm$ from Pascals law P 1 = P 2 $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $F_2 = F_1 x \frac{(r_2)^2}{(r_1)^2}$ $\frac{90000 \times 18 \times 18}{0.9 \times 0.9}$ $F_2 = 36 \times 10^4\ N$
8	Hydraulic lift is a device used to lift heavy loads. State the principle behind the working of this device. Ans:Pascal's law When force is applied on a liquids the pressure is transmitted equally in all directions inside the liquids there fore the hydrostatic pressure has no fixed direction and hence it is a scalar quantity  Let, F_1 --> force on smaller piston. F_2 -->force developed on larger piston. A_1 --> area of smaller piston, A_2 --> area of larger piston. According to Pascal's law, the pressure applied on smaller piston is transmitted with out change at all points in the liquid.

Thus $\frac{F_1}{A_1}=\frac{F_2}{A_2}$

Therefore $F_2=\frac{F_1}{A_1}A_2$

as $A_2 >> A_1$, $F_2 >> F_1$

This shows that the small force applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which a heavy load placed on the larger piston is easily lifted upwards.

Each question scores Four

1 In case of fluids law of conservation of energy can be explained with Bernoulli's principle. State and prove Bernoulli's principle.

Ans:

Bernoulli's theorem:

It states that "for the stream line flow of an ideal liquid, the total energy (sum of pressure energy, potential energy, and kinetic energy) per unit mass remains constant at every cross section through out the flow"

$\frac{P}{\rho}+\frac{V^2}{2}+gh$ or $P+\frac{\rho v^2}{2}+\rho gh$

This is the conservation law of energy for a flowing liquid.

Proof:

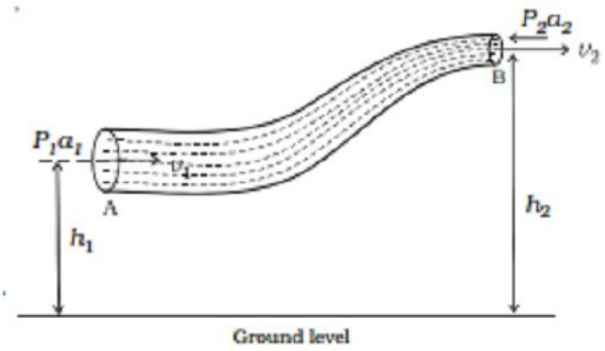


Fig. Bernoulli's theorem

Let
P 1 --> pressure applied at A,
P 2 --> pressure at B,
a 1 --> area of cross section at A,
a 2 --> area of cross section at B,
h 1 --> mean height of section A
h 2 --> mean height of section B,
v 1 --> normal velocity of liquid at A
v 2 --> normal velocity of liquid at B.

ρ--> density of liquid.

Net work done per second on the liquid by the pressure energy in moving the liquid from section A to B = $P_1 V - P_2 V$

[By equation of continuity volume of liquid 'V' flowing per second remains constant]

The increase in potential energy /second of the liquid = $mgh_2 - mgh_1$

The increase in kinetic energy /second of the liquid = $\frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$

According to work energy principle,

work done/second by the pressure energy= increase in PE/second + increase in KE/second.

$$P_1 V - P_2 V = mgh_2 - mgh_1 + \frac{1}{2} mv_{2^2} - \frac{1}{2} mv_{1^2}$$

$$P_1 V + mgh_1 + \frac{1}{2} mv_{1^2} = P_2 V + mgh_2 + \frac{1}{2} mv_{2^2}$$

Dividing by 'm',

$$\frac{P_1 V}{m} + gh_1 + \frac{1}{2} v_{1^2} = \frac{P_2 V}{m} + gh_2 + \frac{1}{2} v_{2^2}$$

$$\frac{P_1}{\rho} + gh_1 + \frac{1}{2} v_{1^2} = \frac{P_2}{\rho} + gh_2 + \frac{1}{2} v_{2^2}$$

ie., $$\frac{P}{\rho} + gh + \frac{1}{2} v^2 = constant.$$

OR $$P + \rho gh + \frac{\rho v^2}{2} = constant$$

Thus, Pressure energy per unit mass+ PE per unit mass + KE per unit mass = a constant.

This proves Bernoulli's theorem

2 Law of conservation of energy is a universal law for all states of matter.

a) Which theorem gives the law of conservation of energy for a flowing liquid?

b) State and prove the above theorem.

Ans:

(a) Bernoulli's theorem

(b) Bernoulli's theorem Statement & Proof

3 a) Is pressure in a liquid, scalar or vector.

Ans: Scalar

b) Briefly explain the working of hydraulic lift.

Ans: A hydraulic lift consists of two cylinders C and D connected to each other by means of a pipe. The two cylinders are of different area of cross-section and are provided with frictionless pistons. The load to be lifted is placed on the platform attached to the larger piston. The space below the pistons of the two cylinders is filled with a liquid such as oil.

Suppose a force f is applied on the smaller piston of cross-sectional area a. Then pressure exerted on the liquid,

P = f/a ----- (1)

According to Pascal's law, the same pressure is transmitted through the liquid to the larger piston of cross-sectional area A. If F is the force transmitted to the larger piston, then

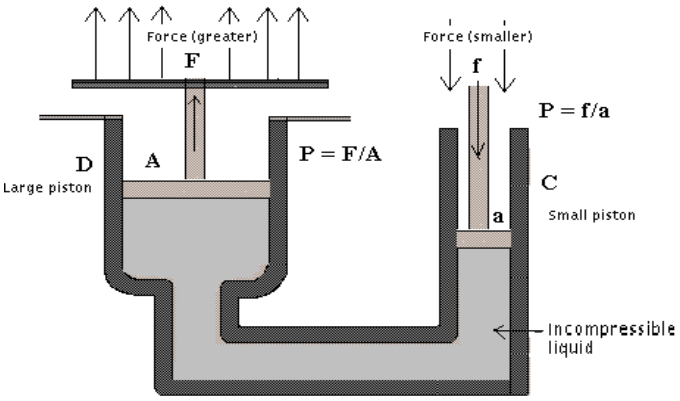
P = F/A ----- (2)

From (1) and (2) we get

F/A = f/a

or $F = \frac{f A}{a}$ ------ (3)

Since A is greater than a, force F on the larger piston will also be much larger than the applied force f. A heavy load placed on larger piston is then easily lifted.



4 A vertical off-shore structure is built to withstand a maximum stress of 10^9 Pa. Is the structure suitable for putting upon top of an oil well in Bombay High? Take the depth of the sea to be roughly 3km, and ignore ocean currents.

Ans:

Pressure at a depth of 3 km (=3000 m) in the sea = ρgh

= (10^3 kg/m^3)(9.8 m/s^2)(3000 m)

= 2.94x10^7 N/m^2

=3×10^2 Pa

Since the structure can withstand a maximum pressure of 10^9 Pa, which is far greater than 3x107 Pa, it is suitable for the purpose.

5 2. A hydraulic automobile lift is designed to lift cars with a maximum mass of 3000 kg. The area of cross-section of the piston carrying the load is 425cm^2. What maximum pressure would the smaller piston have to bear?

Strategy. Express load and cross-section area in SI units. The pressure on the smaller piston is the same as that on the larger piston (Pascal's law)

Ans:

Area of cross-section of the piston carrying load,

A = 425 cm^2 = 425x10^{-4} m^2= 4.25×10^{-2} m^2

Force on the larger piston, F = 3000 kg wt

= 3000x 9.8 N = 2.94×10^4 N

Pressure on the larger piston, P = F/A

=(2.94×10^4 N / 4.25x10^{-2} m^2)

= 6.92×10^5 N/m^2

= 6.92×10^5 Pa

Since pressure is transmitted equally in all directions, pressure on the smaller piston is also 6.92×10^5 Pa

Each question scores Five

1 In case of fluids law of conservation of energy can be explained with Bernoulli's principle
(a) With a neat diagram State and prove Bernoulli's principle.

Ans:
(a) Bernoulli's theorem:

It states that "for the stream line flow of an ideal liquid, the total energy (sum of pressure energy, potential energy, and kinetic energy) per unit mass remains constant at every cross section through out the flow"

$$\frac{P}{\rho}+\frac{V^2}{2}+gh \quad \text{or} \quad P+\frac{\rho v^2}{2}+\rho gh$$

This is the conservation law of energy for a flowing liquid.

Proof:

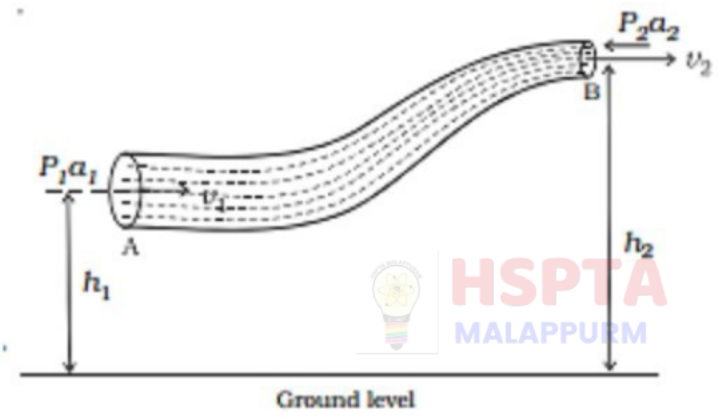


Fig. Bernoulli's theorem

Let
P 1 --> pressure applied at A,
P 2 --> pressure at B,
a 1 --> area of cross section at A,
a 2 --> area of cross section at B,
h 1 --> mean height of section A
h 2 --> mean height of section B,
v 1 --> normal velocity of liquid at A
v 2 --> normal velocity of liquid at B.
ρ--> density of liquid.

Net work done per second on the liquid by the pressure energy in moving the liquid from section A to B = $P_1 V - P_2 V$

[By equation of continuity volume of liquid 'V' flowing per second remains constant]
The increase in potential energy /second of the liquid = $mgh_2 - mgh_1$

The increase in kinetic energy /second of the liquid = $\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

According to work energy principle,
work done/second by the pressure energy= increase in PE/second + increase in KE/second.

$$P_1V - P_2V = mgh_2 - mgh_1 + \frac{1}{2}mv_{2^2} - \frac{1}{2}mv_{1^2}$$

$$P_1V + mgh_1 + \frac{1}{2}mv_{1^2} = P_2V + mgh_2 + \frac{1}{2}mv_{2^2}$$

Dividing by 'm',

$$\frac{P_1V}{m} + gh_1 + \frac{1}{2}v_{1^2} = \frac{P_2V}{m} + gh_2 + \frac{1}{2}v_{2^2}$$

$$\frac{P_1}{\rho} + gh_1 + \frac{1}{2}v_{1^2} = \frac{P_2}{\rho} + gh_2 + \frac{1}{2}v_{2^2}$$

ie., $\frac{P}{\rho} + gh + \frac{1}{2}v^2 = constant.$

OR $P + \rho gh + \frac{\rho v^2}{2} = constant$

Thus, Pressure energy per unit mass+ PE per unit mass + KE per unit mass = a constant.
This proves Bernoulli's theorem

Additional Info : Applications of Bernoulli's theorm:
Attraction between two closely parallel moving boats (or buses)
Working of an Aeroplane (Dynamic lift)
Action of atomiser.
Blowing off roofs by wind storms:
Magnus effect
Venturimeter
When we blow in between two pith balls suspended they will attract each other.
A paper can be held stationary in air by blowing above it.
Blood flow and Heart attack can be explained by Bernoulli's theorm

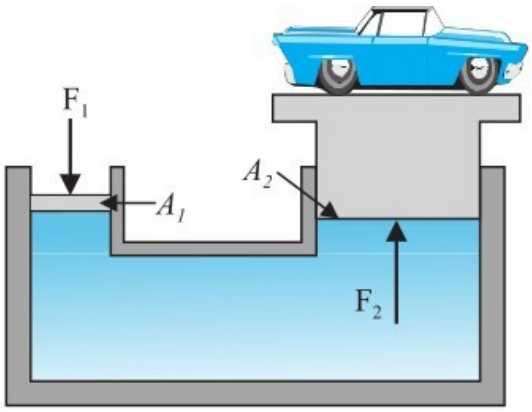
(b) While travelling in aero plane, it is advisable to remove ink from fountain pen. Why?
Ans:
(b) During take off of the plane the pressure inside the plane reduces there fore the pen may leak or ink comes out

2 (a) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area. Explain Why?
(b) State the law associated with liquid pressure. What the SI unit of Pressure
(c) Briefly explain the working of hydraulic lift

Ans:
(a) When force is applied on a liquids the pressure is transmitted equally in all directions inside the liquids there fore the hydrostatic pressure has no fixed direction and hence it is a scalar quantity

(b) Pascal's law. SI unit for pressure is Pascal (Pa)

(c)Hydraulic lift is used to lift the heavy loads. Its working is based on Pascal's law.



Let, F_1 --> force on smaller piston.
F_2 -->force developed on larger piston.
A_1 --> area of smaller piston,
A_2 --> area of larger piston.
According to Pascal's law, the pressure applied on smaller piston is transmitted with out change at all points in the liquid.

Thus $\frac{F_1}{A_1}=\frac{F_2}{A_2}$

Therefore $F_2=\frac{F_1}{A_1}A_2$

as $A_2 >> A_1$, $F_2 >> F_1$

This shows that the small force applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which a heavy load placed on the larger piston is easily lifted upwards.

Note: Other applications of Pascal's law are
i) Hydraulic press (or Brahma press)
ii) Hydraulic brakes.

3 a)Is pressure in a liquid, scalar or vector.
b) State the law associated with liquid pressure.
c) Briefly explain the working of hydraulic lift.

Ans:
a)Scalar
b)Pascal's law
c) working of hydraulic lift.
A hydraulic lift consists of two cylinders C and D connected to each other by means of a pipe. The two cylinders are of different area of cross-section and are provided with frictionless pistons. The load to be lifted is placed on the platform attached to the larger piston. The space below the pistons of the two cylinders is filled with a liquid such as oil.

Suppose a force f is applied on the smaller piston of cross-sectional area a. Then pressure exerted on the liquid,

P = f/a ----- (1)

According to Pascal's law, the same pressure is transmitted through the liquid to the larger piston of cross-sectional area A. If F is the force transmitted to the larger piston, then

$$P = F/A \quad \text{----- (2)}$$

From (1) and (2) we get

$$F/A = f/a$$

$$\text{or} \quad F = \frac{f\,A}{a} \quad \text{------ (3)}$$

Since A is greater than a, force F on the larger piston will also be much larger than the applied force f. A heavy load placed on larger piston is then easily lifted.