Streamline Flow

Have you ever seen a stream passing under the bridge? What do you first observe when you see a streamline? The answer is the most common characteristics of the stream such as speed, width, amount of water flowing etc. One of the primary characteristics of any stream is its flow. We refer to it as streamflow.

Streamflow is the characteristics that determine how the water of the stream will move in a stream channel. Streamflow can either be streamline/laminar flow or turbulent flow. In this topic, we will study the concept of streamline flow.

Introduction

You might have seen streams come in different size, shape, etc. Moreover, they are also different from each other in speed and the flow direction. This topic will help you to understand one of a primary way of flow.

An important factor that influences the flow of water within streams is the location or source of the stream. Different sources include rainfall, the ground below the stream or even melting snow. The source location of the stream has the potential to influence the speed of the water as well as the manner of flow within the stream.

Another important factor influencing the flow within the stream is the object that is physically present in the stream. The direction and speed of the flowing water are dependent on the object found in the stream. The major characteristic of the streamflow of a liquid is velocity. Therefore, on the basis of the above characteristics water can either be streamline/laminar flow or turbulent flow.

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- Streamline Flow
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Definition of Streamline Flow

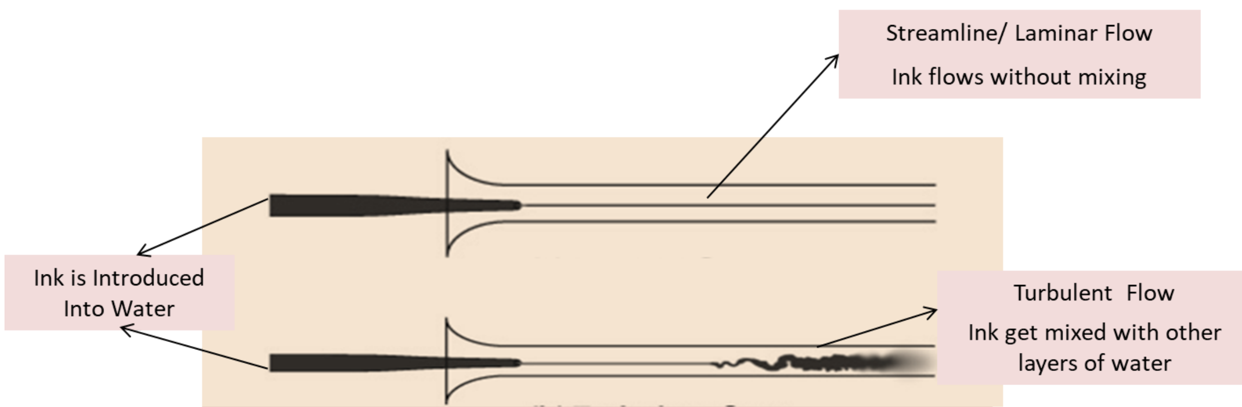
Streamline flow in case of fluids is referred to as the type of flow where the fluids flow in separate layers without mixing or disruption occurring in between the layers at a particular point. The velocity of each fluid particle flowing will remain constant with time in streamline flow.

In case of low fluid velocities, the fluid will flow without any sort of lateral mixing because of lack of turbulent velocity fluctuations. The fluid particles tend to follow a particular order where the movement or motion of fluid particles will be on the basis of particles flowing in a straight line parallel to the pipe wall. The movement happens in a way that the adjacent layers of the fluid will smoothly slide past each other.

Examples of Streamline and Turbulent Flows

Notice water flowing from a tap at a different flow rate. You will observe that when the flow rate is low the water flowing from the tap will run smoothly and the water will have a smooth texture. However, if you gradually keep on increasing the flow rate you will begin to see the disturbances and voids after a particular point of increasing the flow rate.

Now, in both cases, the introduction of ink will give different results. When you will introduce a stream of ink in the first case where water is flowing smoothly, the ink will not mix with other layers. However, if we introduce the ink in case of turbulent flow, the ink will mix with other layers of water. The first type of condition is a streamline flow.



Demonstration of Streamline & Turbulent Flow

Fluid Dynamics

We have mostly studied about fluids at rest but streamline flow is an example of fluids in motion. It is an important part of fluid dynamics (the study of fluids in motion). We have learned how opening a water tap slowly is responsible for the smooth flowing of water. But the smoothness is lost as we gradually keep on increasing the outflow speed.

Here we will focus on what will happen to the various fluid particles at a certain point in space at a particular time.

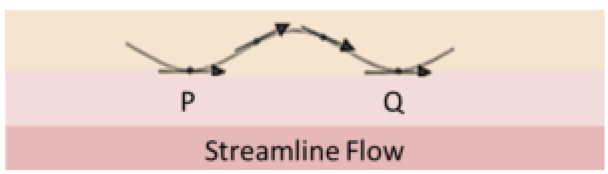
Steady Flow

The flow is steady when the velocity of every particle within the fluid is constant in time. However, this statement does not mean that the velocity of fluid particles will not vary at a different point in space. The velocity of a fluid particle can change as the fluid moves from one particular point to the other.

This means that at a different point the particle can have a different velocity. Steady flow signifies that each particle passing through the second point will behave the same as the previous fluid particle that has initially crossed that point. Therefore, under steady flow condition, the fluid particles will follow a smooth path that will not cross each other.

Hence, streamline is the path taken by fluid particles under the steady flow condition. In case of a streamline flow, the tangent drawn at any point of the curve (path) will be in direction of the velocity of the fluid at that point.

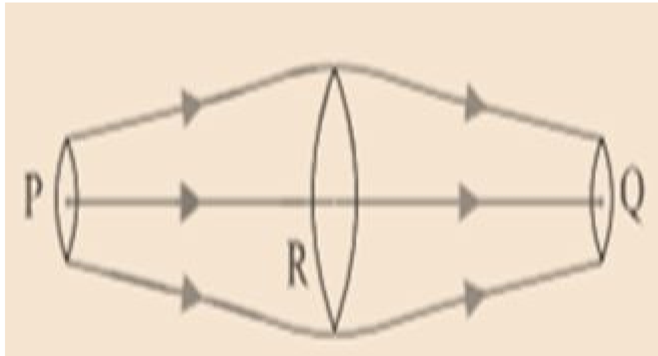
Below diagram represents a curve with tangents at different points. It describes how the particles present within a fluid moves with respect to time.



The diagram act as a permanent map to describe how the fluid flows during streamlines condition. Thus, no two streamlines can intermix or cross each other. Under steady flow, the map of the movement of fluid is stationary with respect to time. Hence, the continuum of lines will form if we try to describe the streamline flow of every particle.

Derivation of Streamline Flow

Consider three parts (P, R, and Q) in planes that are present in the perpendicular direction to the fluid. Refer to the diagram below



We will be able to determine the boundaries the selected points in the plane by the same set of the streamlines. Hence, the particles of fluid passing through the surfaces at the three-point P, R and Q will be the same. Now consider the area at the three points as A_P, A_R, and A_Q. Consider the speed of the fluid particles as v_P, v_R, and v_q.

Now, we will calculate the mass of fluids. The mass of the fluid m_P crossing at the area A_P at a small time interval t will be "ρ_P A_P v_P t". Similarly, the mass of fluid m_R and m_Q will be "$\rho_R A_R$ v_R t" and "ρ_Q A_Q v_Q t" passing at A_P and AQ respectively at a small interval of time Ät.

In all the three cases, the mass of liquid flowing in and flowing will be equal. Therefore, we can write the equation as

ρ_P A_P v_P t = $\rho_R A_R$ v_R t= ρ_Q A_Q v_Q t

If we consider the fluids as incompressible in nature then "$\rho_P = \rho_R = \rho_Q$" will be equal. So the above equation can be rewritten as

$A_P v_P = A_R v_R = A_Q v_Q$ (after elimination of ρ)

The above equation is the *equation of continuity*. The equation also represents conservation of mass in case of the flow of the incompressible liquids.

General Equation of Continuity

$$Av = \text{Constant}$$

where Av is the flow rate of the liquid or volume flux of the liquid. The flow rate in case of streamline flow remains constant throughout the flow of liquid through the pipe. Hence, the streamlines in narrower regions are present closely thereby resulting in the increase of velocity and vice versa.

From the above diagram, the area of R will be greater than Q. Thus velocity in the R will be less than Q. Thus, the fluid will increase in velocity while crossing from R to Q. Therefore, it is easy to acquire steady flow at low fluid flow speed. However, after reaching a particular speed, the flow will lose its steadiness and gradually tend to become turbulent.

This speed is called critical speed. The classic example of streamline flow to turbulent flow is the formation of white-water rapids when a fast-moving stream comes in contact with rocks.

Solved Examples for You

Question: Mention the correct direction of streamline and equipotential line in a flow field

1. Identical to each other
2. Parallel to each other
3. Perpendicular to each other
4. Intersect each other at acute angles

Solution: Option 3 (Perpendicular to each other)

Surface Tension

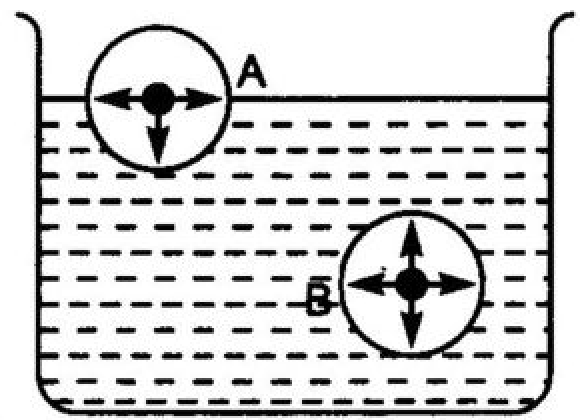
Have you ever noticed that people heat glass to round off the sharp edges? Why do they do that? Why doesn't the glass break or melt?

This is the concept of surface tension. In this chapter, we will look at this concept in greater depth. We will also discuss a few practical applications of the surface tension.

Surface Tension

Surface tension is the property of liquid which arises due to the fact that the molecules of the liquid at the surface are in a different situation than those in the interior of the liquid. A molecule lying inside the liquid is surrounded by other molecules and so is attracted equally in all directions. Hence, the net force of attraction acting on the molecule is zero.

A molecule lying on the surface is attracted more by the molecules lying in the bulk of the liquid than by the molecules lying above it in the vapour phase. A molecule lying on the surface experiences a net inward attraction. As a result of this inward pull on all molecules lying on the surface, the surface behaves as if it were under tension.



In other words, the surface tension of a liquid is defined as the force acting at right angles to the surface along 1 cm length of the surface. Thus, the units of surface tension are dynes per centimetre or Newton per metre i.e. Nm^{-1} in the S.I. system.

As a result of inward pull on the molecules at the surface, the surface of the liquid tends to the smallest possible area for a given volume of the liquid. This gives the lowest energy state of the liquid. The drop of a liquid is spherical because, for a given volume, a sphere has minimum surface area.

The work in ergs required to be done to increase or extend the surface area by 1 sq cm is called surface energy. The units of surface energy are, therefore, ergs per sq cm or joules per sq m in S.I. system.

Surface Energy = work per sq cm= (Force× length) per sq cm = dynes cm^{-1}

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The Spherical Shape of Droplets

The lowest energy state of a liquid will be when the surface area is minimum. Surface tension tries to decrease the surface area of the liquid to the minimum. The drops of a liquid are spherical because, for a given volume, a sphere has minimum surface area.

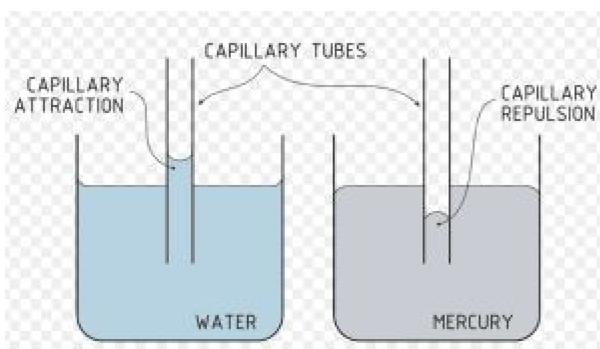
Fire Polishing of Glass

Sharp glass edges are heated to make them smooth. This is because, on heating, the glass melts and takes up rounded shape at the edges which have minimum surface area. This is called fire polishing of glass.

The Rise of Liquids in Capillary Tubes

If one end of a capillary tube is put into a liquid that wets glass, it is found that the liquid rises into the capillary tube to a certain height. This rise is due to the inward pull of surface tension acting on the surface which pushes the liquid into the capillary tube. It is because of the same reason that oil rises into the Wick of an oil lamp or water below the surface of the earth rises in the plant or ink in a blotting paper.

In case of liquids which do not wet glass, like Mercury, the level inside the capillary falls below the level outside, whereas the upper surface of a liquid that wets glass is concave, that of mercury is convex.



A meniscus is a curved surface of a liquid. Cohesive forces are the attractive forces existing between the molecules of the same substance. For example, the cohesive force exists between the molecules of water or molecules of Mercury.

Adhesive forces are the attractive forces existing between the different substances. For example, adhesive forces exist between water and glass or Mercury and glass. In case of water taken in a glass tube, adhesive forces are stronger than Cohesive forces whereas it is reverse for Mercury taken in a glass tube.

Solved Examples for You

Q: Describe the effect of nature of liquid and temperature on surface tension.

Solution: Surface tension is a property that arises due to the intermolecular forces of attraction among the molecules of the liquid. Greater are the intermolecular forces of attraction, higher is the surface tension of that liquid. Now, let us explain the effect of temperature on surface tension.

The surface tension of liquid generally decreases with the increase in temperature and becomes zero at the critical temperature. The decrease in surface tension with an increase of temperature is due to the fact that with an increase in temperature, the kinetic energy of the molecules increases. Therefore, the intermolecular attraction decreases.

Q: The radii of the two columns is U-tube are r_1 and r_2. When a liquid of density ρ (angle of contact is 0^o) is filled in it, the level difference of liquid in two arms is h. Find out the surface tension of the liquid.

Solution: We know that, $h = 2T/r\rho g$

So, $h_1 = 2T/r_1\rho g$

$h_2 = 2T/r_2\rho g$

$h_1 – h_2 = h = 2T/\rho g(1/r_1 – 1/r_2)$

Thus, $T = h\rho g r_1 r_2/2(r_2 – r_1)$

If the respective values are known, an exact value of surface tension can be obtained.

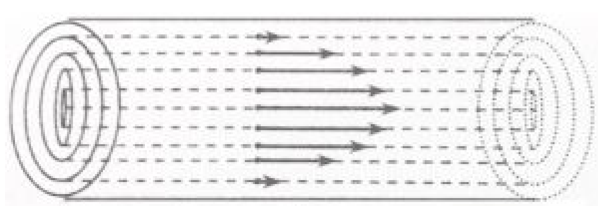
Viscosity

Have you ever noticed that some liquids like water flow very rapidly while some others like castor oil do not flow fast? Why is it so? Didn't that question occur to you yet? Well, if it did, we have the answer to it! This is the concept of Viscosity. In this chapter, we will study all about the topic and look at the laws and examples of the same.

Viscosity

It is the internal resistance to flow possessed by a liquid. The liquids which flow slowly, have high internal resistance. This is because of the strong intermolecular forces. Therefore, these liquids are more viscous and have high viscosity.

The liquids which flow rapidly have a low internal resistance. This is because of the weak intermolecular forces. Hence, they are less viscous or have low viscosity.



Laminar Flow

Consider a liquid flowing through a narrow tube. All parts of the liquids do not move through the tube with the same velocity. Imagine the liquid to be made up of a large number of thin cylindrical coaxial layers. The layers which are in contact with the walls of the tube are almost stationary. As we move from the wall towards the centre of the tube, the velocity of the cylindrical layers keeps on increasing till it is maximum at the centre.

This is a laminar flow. It is a type of flow with a regular gradation of velocity in going from one layer to the next. As we move from the centre towards the walls, the velocity of the layers keeps on decreasing. In other words, every layer offers some resistance or friction to the layer immediately below it.

Viscosity is the force of friction which one part of the liquid offers to another part of the liquid. The force of friction f between two layers each having area A sq cm, separated by a distance dx cm, and having a velocity difference of dv cm/sec, is given by:

$$f \propto A \, (dv / dx)$$

$$f = \eta A \, (dv/dx)$$

where η is a constant known as the coefficient of viscosity and dv/dx is called velocity gradient. If dx =1 , A = 1 sq cm; dv = 1 cm/sec, then $f = \eta$. Hence the coefficient of viscosity may be defined as the force of friction required to maintain a velocity difference of 1 cm/sec between two parallel layers, 1 cm apart and each having an area of 1 sq cm.

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Units of Viscosity

We know that: $\eta = f .dx / A .dv$. Hence, η = dynes × cm / cm^2 ×cm/sec. Therefore we may write: η = dynes cm^{-2} sec or the units of viscosity are dynes sec cm^{-2}. This quantity is called 1 Poise.

$f = m \times a$

$\eta = (m \times a \times dx) / (A .dv)$

Hence, η = g cm^{-1} s^{-1}

Therefore, η = 1 poise

In S.I. units, η = f .dx / A .dv

= N × m / (m^2 × ms^{-1})

Therefore we may write, η = N m^{-2} or Pas

1 Poise = 1 g $cm^{-1}s^{-1}$ = 0.1 kg m^{-1} s^{-1}

Solved Examples For You

Q: The space between two large horizontal metal plates 6 cm apart, is filled with a liquid of viscosity 0.8N/m. A thin plate of surface area 0.01m^2 is moved parallel to the length of the plate such that the plate is at a distance of 2m from one of the plates and 4cm from the other. If the plate moves with a constant speed of 1ms^{-1}, then:

A. Fluid layer with the maximum velocity lies midway between the plates.
B. The layer of the fluid, which is in contact with the moving plate, has the maximum velocity.

C. That layer which is in contact with the moving plate and is on the side of the farther plate is moving with maximum velocity.
D. Fluid in contact with the moving plate and which is on the side of the nearer plate is moving with maximum velocity.

Solution: B) The two horizontal plates are at rest. Also, the plate in between the two plates, is moving ahead with a constant speed of $1 ms^{-1}$. The layer closest to this plate will thus move with the maximum velocity.

Bernoulli's Principle and Equation

Do you know even common garden equipment such as garden hose in certain situations can follow the Bernoulli's principle? A garden hose can really be an effective piece for tormenting people by simply following Bernoulli's principle/ Bernoulli's equation. How? Let us understand.

Water runs out of garden hose but if you use your thumb and block a part of the opening of the hose, it will release the water faster which most definitely can soak anyone near the vicinity, hence, the torment part. However, if we remove the finger, the flow will be back to normal. Bernoulli's principle forms the basis of this phenomenon.

Bernoulli's Equation and Principle

Bernoulli's principle, also known as Bernoulli's equation, will apply for fluids in an ideal state. Therefore, pressure and density are inversely proportional to each other. This means that a fluid with slow speed will exert more pressure than a fluid which is moving faster.

In this case, fluid refers to not only liquids but gases as well. This principle forms the basis of many applications. Some very common examples are an aeroplane that tries to stay aloft or even the most common everyday things such as a shower curtain billowing inward.

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The same phenomenon happens in the case of the river when there is a change in the width of the river. The speed of the water decreases in wider regions whereas the speed of water increases in the narrower regions.

You will think that the pressure within the fluid will increase. However, contrary to the above statement, the pressure within the fluid in the narrower parts will decrease and the pressure inside the fluid will increase in the wider parts of the river.

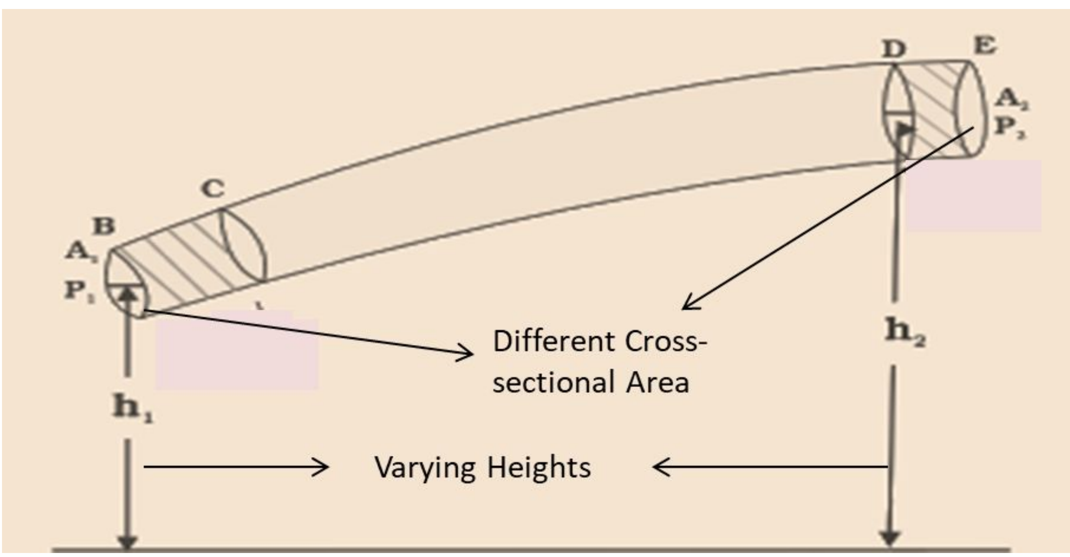
Swiss scientist Daniel Bernoulli while experimenting with fluid inside the pipes led to the discovery of this concept. He observed in his experiment that the speed of the fluid increases but the internal pressure of the fluid decreases. He named this concept as Bernoulli's principle.

Definitely, the concept is difficult to understand and quite complicated. It is possible to think that the pressure of water will increase in tighter spaces. Indeed, the pressure of water increases in the tighter spaces but pressure within the water will not increase.

Thus, the surrounding of the fluid will experience the increase in the pressure. The change in the pressure will also result in the change in speed of the fluid. Now, let us understand this concept clearly.

Deriving Bernoulli's Equation

Mechanism of fluid flow is a complex process. However, it is possible to get some important properties with respect to streamline flows by using the concept of conservation of energy. Let us take an example of any fluid moving inside a pipe. The pipe has different cross-sectional areas in different parts and is present in different heights. Refer to the diagram below.



Now we will consider that an incompressible fluid will flow through this pipe in a steady motion. As per the concept of the equation of continuity, the velocity of the fluid should change. However, to produce acceleration, it is important to produce a force. This is possible by the fluid around it but the pressure must vary in different parts.

Bernoulli's equation is the general equation that describes the pressure difference in two different points of pipe with respect to velocity changes or change in kinetic energy and height changes or change in potential energy. The relationship was given by Swiss Physicist and Mathematician "Bernoulli" in the year 1738.

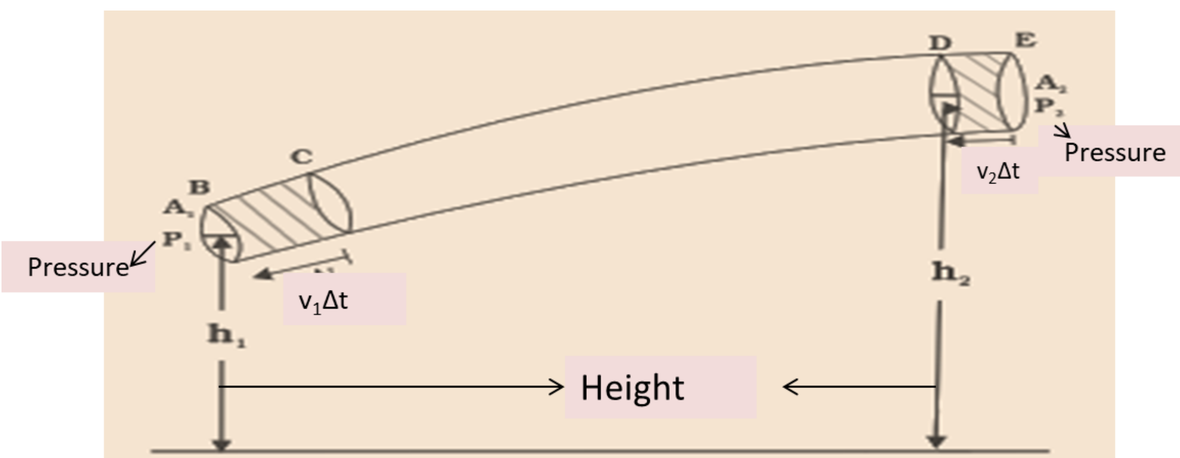
Learn more about Surface Tension here in detail.

General Expression of Bernoulli's Equation

Let us consider two different regions in the above diagram. Let us name the first region as BC and the second region as DE. Now consider the fluid was previously present in between B and D. However, this fluid will move in a minute (infinitesimal) interval of time (Δt).

If the speed of fluid at point B is v_1 and at point D is v_2. Therefore, if the fluid initially at B moves to C then the distance is $v_1\Delta t$. However, $v_1\Delta t$ is very small and we can consider it constant across the cross-section in the region BC.

Similarly, during the same interval of time Δt the fluid which was previously present in the point D is now at E. Thus, the distance covered is $v_2\Delta t$. Pressures, P_1 and P_2, will act in the two regions, A_1 and A_2, thereby binding the two parts. The entire diagram will look something like the figure given below.



Movement of Fluid from $v_1\Delta t$ to $v_2\Delta t$ in Δt Time Interval

Demonstration of Flow of an Ideal Fluid in Pipe having Different Cross-section

Finding the Work Done

First, we will calculate the work done (W_1) on the fluid in the region BC. Work done is

$W_1 = P_1A_1 (v_1\Delta t) = P_1\Delta V$

Moreover, if we consider the equation of continuity, the same volume of fluid will pass through BC and DE. Therefore, work done by the fluid on the right-hand side of the pipe or DE region is

$W_2 = P_2A_2 (v_2\Delta t) = P_2\Delta V$

Thus, we can consider the work done on the fluid as $– P_2\Delta V$. Therefore, the total work done on the fluid is

$W_1 – W_2 = (P_1 − P_2) \Delta V$

The total work done helps to convert the gravitational potential energy and kinetic energy of the fluid. Now, consider the fluid density as ρ and the mass passing through the pipe as Δm in the Δt interval of time.

Hence, $\Delta m = \rho A_1 v_1\Delta t = \rho\Delta V$

Learn more about Viscosity here in detail.

Change in Gravitational Potential and Kinetic Energy

Now, we have to calculate the change in gravitational potential energy ΔU.

$$\Delta U = \rho g \Delta V (h_2 - h_1)$$

Similarly, the change in ΔK or kinetic energy can be written as

$$\Delta K = \left(\frac{1}{2}\right) \rho \, \Delta V (v_2^2 - v_1^2)$$

Calculation of Bernoulli's Equation

Applying work-energy theorem in the volume of the fluid, the equation will be

$$(P_1 - P_2)\, \Delta V = \left(\frac{1}{2}\right) \rho \, \Delta V (v_2^2 - v_1^2) + \rho g \Delta V (h_2 - h_1)$$

Dividing each term by ΔV, we will obtain the equation

$$(P_1 - P_2) = \left(\frac{1}{2}\right) \rho (v_2^2 - v_1^2) + \rho g (h_2 - h_1)$$

Rearranging the equation will yield

$$P_1 + \left(\frac{1}{2}\right) \rho v_1^2 + \rho g h_1 = P_2 + \left(\frac{1}{2}\right) \rho v_2^2 + \rho g h_2$$

The above equation is the Bernoulli's equation. However, the 1 and 2 of both the sides of the equation denotes two different points along the pipe. Thus, the general equation can be written as

$$P + \left(\frac{1}{2}\right) \rho v^2 + \rho g h = \text{constant}$$

Thus, we can state that Bernoulli's equation state that the Pressure (P), potential energy (ρgh) per unit volume and the kinetic energy (ρv2/2) per unit volume will remain constant.

Important Points to Remember

It is important to note that while deriving this equation we assume there is no loss of energy because of friction if we apply the principle of energy conservation. However, there is actually a loss of energy because of internal friction caused during fluid flow. This, in fact, will result in the loss of some energy.

Limitations of the Applications of Bernoulli's Equation

One of the restrictions is that some amount of energy will be lost due to internal friction during fluid flow. This is because fluid has separate layers and each layer of fluid will flow with different velocities. Thus, each layer will exert some amount of frictional force on the other layer thereby losing energy in the process.

The proper term for this property of the fluid is viscosity. Now, what happens to the kinetic energy lost in the process? The kinetic energy of the fluid lost in the process will change into heat energy. Therefore, we can easily conclude that Bernoulli's principle is applicable to non-viscous fluids (fluids with no viscosity).

Another major limitation of this principle is the requirement of the incompressible fluid. Thus, the equation does not consider the elastic energy of the fluid. However, elastic energy plays a very important role in various applications. It also helps us to understand the concepts related to low viscosity incompressible fluids.

Furthermore, Bernoulli's principle is not possible in turbulent flows. This is because the pressure and velocity are constantly fluctuating in case of turbulent flow.

What will happen to Bernoulli's equation if a fluid is at rest or the velocity is zero?

When the velocity is zero, the equation will become

$$P_1 + \rho g h_1 = P_2 + \rho g h_2$$
$$(P_1 - P_2) = \rho g (h_2 - h_1)$$

This equation is the same as the equation of pressure with depth, that is,

$$P2 - P1 = \rho gh.$$

Solved Examples for You

Question: Which of the following fluid flow do not follow Bernoulli's equation?

1. Unsteady
2. Rotational
3. Turbulent
4. All of the above

Solution: Option 4. The equation is applicable only to streamline and steady flows.

Pressure and Its Applications

Pressure, which is defined as the force over a given area, plays a number of important roles in daily life. It is a varied concept with various applications. In this chapter let us study about pressure and its application in detail.

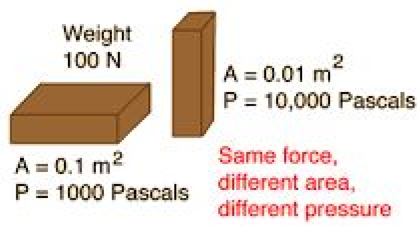
Force, Pressure and Its Applications

Pressure is the force per unit area. The SI Unit of Pressure is the pascal (Pa). A pascal can be defined as a force of one newton applied over a surface area of one meter square. In other forms,

Pressure = Force / Area

The pressure is dependent on the area over which the force is acting, without any change in the force, the pressure can be increased and decreased. The Force applied to be constant if the surface becomes smaller the pressure increases and vice versa.

$$Pressure = \frac{Force}{Area} = \frac{F}{A}$$

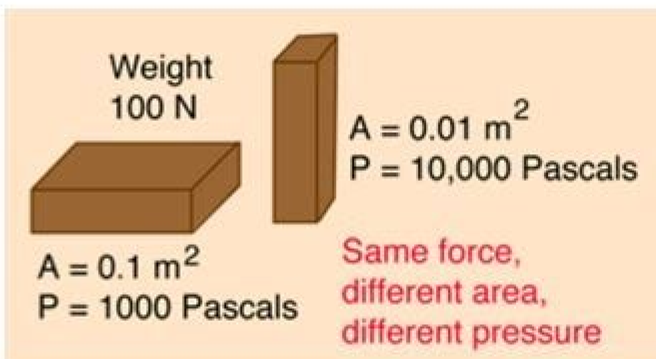


Some Practical Examples

Let us take an example of pressure: take into consideration a sharp needle, it has a small surface area. However, consider a pencil which is very blunt in the back. It has more surface area than the needle. If we poke the needle in our palm, it will definitely hurt us as the needle gets pierced inside our skin whereas if we poke the blunt side of the pencil into our hand it wouldn't pain at all.

It is due to the fact that the area of contact between the palm and the needle is very small, further the pressure is in a way large. However, the area of contact between the pencil and the palm is more, therefore the pressure is less.

Another example we can take as – A brick sitting on a surface exerts a force equal to its weight on the object it is resting on. Now we know that a rectangular brick has a wide surface and thin surfaces on the sides. By changing the orientation of the brick resting on a surface, we are effectively changing the pressure acting on the surface by the same brick. You can refer to the image below for other information –



<TO BE REDRAWN>A example illustrating how changing the surface area over which the force is acting changes the pressure on the surface.

By this we can conclude that the two factors that determine the magnitude of the pressure are:

- Force: The force which states that the greater the force, the greater is the pressure and vice-versa.

- Coverage Area: which states that the greater the area less is the pressure and vice-versa.

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- Bernoulli’s Principle and Equation

What is Bernoulli’s Principle and Equation?

Daily Life Pressure and Its Application

The application of atmospheric pressure, or in simple words, air pressure is referred to as the numerous activities that we do or observe every day without a realization of any kind of push or pressure. We are able to survive this high-pressure condition as we have evolved and somewhere managed our body functions withstand this amount of high pressure.

Solved Example for You on Pressure and Its Application

Question. What is the excess pressure inside a bubble of soap solution of radius 5.00 mm, given that the surface tension of soap solution at the temperature (20 °C) is 2.50×10^{-2} N m^{-1}? If an air bubble of the same dimension were formed at depth of 40.0 cm inside a container containing the soap solution (of relative density 1.20), what would be the pressure inside the bubble? (1 atmospheric pressure is 1.01×10^{5} Pa).

Solution: Excess pressure inside the soap bubble is 20 Pa;

Soap bubble is of radius, $r = 5.00$ mm $= 5 \times 10^{-3}$ m

The surface tension of the soap solution, $S = 2.50 \times 10^{-2}$ Nm^{-1}

A relative density of the soap solution = 1.20

Density of the soap solution, $\rho = 1.2 \times 10^{3}$ kg/m^{3}

Air bubble formed at a depth, $h = 40$ cm $= 0.4$ m

Radius of the air bubble, r = 5 mm = 5×10^{-3} m

1 atmospheric pressure = 1.01×10^5 Pa

Acceleration due to gravity, g = 9.8 m/s^2

Hence, the excess pressure inside the soap bubble is:

$P=4S/r$

$=(4\times2.5\times10^{-2})/5\times10^{-3}$

=20Pa

Therefore, the excess pressure inside the soap bubble is 20 Pa. The excess pressure inside the air bubble is :

$P'=2S/r$

$=(2\times2.5\times10^{-2})/5\times10^{-3}$

=10Pa

Therefore, the excess pressure inside the air bubble is 10 Pa. At a depth of 0.4 m, the total pressure inside the air bubble,

Atmospheric pressure + hρg + P'

$=1.01\times10^5+0.4\times1.2\times10^3 x 9.8+10$

$=1.057\times10^5 Pa$

$=1.06\times10^5 Pa$

Therefore, the pressure inside the air bubble is 1.06×10^5 Pa.

This concludes our discussion on the topic of pressure and its application.