PHYSICS

BOOKS - S CHAND PHYSICS (ENGLISH)

MOTION IN FLUIDS

Examples

1. A vessel of length l, breadth b and height h is filled completely with a liquid of density d

(see figure) Calculate the thrust on each surface of the cube.

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2. What is the pressure in an ocean at a depth of 1000 m, if the density of water is $1.024 \times 10^3 \frac{kg}{m^3}$. Atmospheric pressure $P. = 1.01 \times 10^5$ Pa.

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3. A plece of ice floats in a beaker containing water with a certain fraction inside water. If the density of ice is D and that of water is ρ find the value of n. What will happen to the level of water when the ice completely melts ?

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4. A piece of wood floats in water with two-thirds of its volume submerged in water. In a

certain oil it has 0.95 of its volume submerged. What is the density of wood and the oll?

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5. A cube is floating on mercury with $(1/5)^{th}$ of its volume submerged. If suficient water Is added to cover the cube, what fraction of its volume will remain immersed in mercury ? Density of mercury = $13600 kg/m^3$.

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6. A metal block of area $0.10m^2$ is connected to a 0.010 kg mass via a string that passes over an ideal pulley (cosidered massless and frictionless). As in figure. A liquid with a film thickness of 0.30 mm is placed b etween the block and the table. when released the block moves to the right with a constant speed of $0.085ms^{-1}$. find the coefficient of viscosity of the liquid.

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7. An iron sphere of diameter 10 mm falls through a column of oil of density $940 kg/m^3$. The density of iron is. $7.8 \times 10^3 kg/m^3$. The coefficient of viscosity of oll is$4.48 Ns/m^2$. Caleulate the terminal velocity attained by the ball.

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8. Calculate the terminal velocity with which an air bubble of diameter 0.8 mm rises in a liquid

of viscosity $0.250 Ns/m^2$ and density $0.95x10^3 kg/m^3$. Density of air is $1.3 kg/m^3$

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9. Water is flowing through a horizontal tube of length 0.25 m and radius 4×10^{-4} m under a constant pressure head of 0.2 m of water, at the rate of $5 \times 10^{-6} m^3$ per minutre . Calculate the coefficient of visosity of water. Density of water = 1000 kg m^{-3}

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10. To the bottom of a vessel containing alcohol of density $800kg/m^3$ a capillary tube of length 24 cm and diameter 1 mm is fitted horizontally. The axis of the capillary tube is at a depth of 36 em from the surface of the alcohol. The coefficient of viscosity of alcohol is $0.0012Ns/m^2$. Calculate the mass of alcohol flowing out in 10 minutes, assuming that the height of the alcohol remains constant.

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11. In the variable pressure head method of determining the coefficient of viscosity, the heleht of water above the axis of capillary tube before and after the experiment was 45 cm and 55 em respectively. A capillary tube of length 10 cm and diameter 0-4 mm was used. Calculate the coefficient of viscosity of water if the volume of water collected per minute is $1.86x10^{-6}m^3$

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12. A 20-0 litre bucket can be filled with water using a water hose 3-00 cm in diameter in 2 minutes. Calculate the speed with which the water leaves the hose.

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13. Water is nowing through a horizontal pipe of varying cross-section. At a certain point where the velocity is 0-24 m/s the pressure of water is 0-010 metre of mercury. What is the

pressure at a point where the velocity is $0 - 48\frac{m}{s}$?

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14. An engine pumps water from a tank at the rate of 10 kg per second and ejects from a nozzle 7 m above the surface of the tank with a velocity of 20 m/s. What is the output power of the engine?

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15. A venturimeter has a threat of diameter 0-06 m. The diameter of the horizontal pipeline where the venturimeter is inserted is 0-1 m. The pressure difference between the mainline and the throat is 0-32 of water. Calculate the rate of now of water in the pipeline. ?

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16. Calculate the speed with which wafer emerges from a hole in a tank at which the gauge pressure is $3 \times 10^5 N/m^2$?

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17. A water tank has a hole at a distance of 7 m from free water surface. Find the velocity of water through the hole. If the radius of the hole is 2 mm what is the rate of flow of water?

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18. A pilot tube is shown in fig. the fluid in the tube is mercury of density $13,600 kg/m^3$ and

the difference in level of mercury in the tube is 6 cm. What is the speed of air flow ? Density of air is $1.25kg/m^{-3}$

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19. An iron ball has an air space in it, the ball weights ong kg in air and O-6 kg in water. Find the volume of the air space. Density of iron is $7200kgm^{-3}$.

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20. A piece of cork whose weight is 19 gm is attached to a bar of silver weighing 63 gm. The two together just not in water. The specific gravity of silver is 10-5. Find the specific gravity of the cork. Density of water = $1gmcm^{-3}$

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21. A piece of alloy of gold and silver weighs 2 kg in air and 1.86 kg in water. What is the mass

of silver? Density of gold is $19.3 \times 10^3 kgm^{-3}$. Density of silver is $10.5 \times 10^3 kgm^{-3}$

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22. A metal plate $5cm \times 5$ cm rests on a layer of castor oil 1 mm thick whose coefficient of viscosity is $1.55Nsm^{-2}$. Find the horizontal foce required to move the plate with a speed of 2 cm/s

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23. Water is flowing through a horizontal tube of length 0.25 m and radius 4×10^{-4} m under a constant pressure head of 0.2 m of water, at the rate of $5 \times 10^{-6} m^3$ per minutre . Calculate the coefficient of visosity of water. Density of water = 1000 kg m^{-3}

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24. Alcohol flows through two capillary tubes under a pressure lead. The diameter of the two tubes are in the ratio of 4:1 and the

length are in the ratio of 1:4. Compare the rate of flow of alcohol through the two tubes.

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25. With what terminal velocity will an air bubble of radius 0.2 mm. rise in a liquid of viscosity $0.15Nsm^{-2}$ and specific gravity 0.9 ? Density of air$1.3kgm^{-3}$

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26. A pipe is running full of water. At a certain point A It tapers from 60 cm diameter to 20 cm at B. The pressure difference between A and B is 1 m of water column. Find the rate of flow of water through the pipe.

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27. A Pitot tube is fixed in a main of diameter 25 cm and the difference of pressure indicated by the guage is 6 em of water column. Find the

volume of water passing through the main in two minutes ?

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28. A Pitot tube mounted on an aeroplane contains alcohol and shows a level difference of 50 em. What is the speed of the plane relative to uir? (Density of alcohol $800kgm^{-3}$ density of air $-1kgm^{-3}$)

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29. Eight equal drops of water are falling through air with a steady velocity of $0.1ms^{-1}$ combine to form a single drop, what should be the new terminal velocity.

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30. What should be the maximum average velocity of water in a tube of diameter 2 em so

that the flow is laminar ? Viscosity of water is $10^{-3} Nsm^{-2}$? For laminar flow R-1000.

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31. Consider a uniform U-tube with a diaphragm at the bottom and filled with a liquid to different heights in each limb as shown in Fig. Now imagine that the diaphragm is punctured so that the liquid flows from left to right. (a) Show that the application of Bernoulli's particle to points (1)

and Diaphragm (2) leads to a constradiction. (b) Explain why Bernoulli's principle is not applicabe here

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32. A tank is filled with water upto a height H. A hole is punched in one of the walls at a depth h_1 below the water surface. (a) Find the distance from the foot of the wall at which the stream strikes the floor. (6) Is it possible to make second hole at another depth so that

this second stream also has the same range? If so find its depth ?

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33. Air flows over the top of an aeroplane wing of area A with speed v_1 and past the under side of the wing of area A with speed v_2 Show that the magnitude of the upward in force on the wing L is L = $\frac{1}{2}\rho A\left(v_1^2 - v_2^2\right)$ where ρ is the density of the alr.

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Conceptual Short Answer Questions With Answers

1. Hydrostatic pressure is a scalar quantity, even though pressure is force divided by area and force is a vector? Why?

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2. (a) Ice floats in water with about wine-tenths of its volume submerged. What is the fraction

sub merged for an iceberg floating on freshwater lake of a hypothetical) planet whose gravity is to times that of the earth?

(b) What is the fractional volume submerged of an ice cube in a fall of water placed in an enclosure which is freely falling under gravity?

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3. The force required by a man to move his limbs immersed in water is smaller than the force for the some movement in air Why?

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4. A piece of iron sinks in water, but a slip made of iron floats in water. Why?

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5. A man is sitting in a boat, which is floating in a pond. If the man drink some water from the pond, will the level of water in the pond decrease ?

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6. About floaring in a water tank is carrying a number of large stones. If the stories were unloaded into water what will happen to water level?

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7. An ice block with a cork piece embedded inside floats in water.What will happen to the level of water when ice melts ?

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8. What is the effect temperature on coeffieient of viscosity of a liquid ?

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9. What is the reason for floating of clouds in the sky?

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10. Bubbles of air can rise up through a liquid

Why?

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11. When we try to close a water tap with our fingers, fastjets of water yush through the eyeing between our fingers why?

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12. Explain why a fluid flowing out of a small hole in a vessel results in a backward thrust on the vessel.

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13. Roofs of the huts are blown up during stormy days. Why?

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14. To keep a piece of paper horizontal, you should blow over, not under it. Why?

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15. Why does strong winds are blowing on a certain day?

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16. When air is blown In between two balls suspended close to each other they are attracted towards each other why?

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Long Answer Questions

1. The viscous drug on a sphere of medis, moving through a fluid with velocity can be expressed as$6\pi\eta$ where η is the coefficient of

viscosity of the fluid. A small sphere of radius a and density σ is released from the bottom of a column of liqaid of density ρ. If ρ ger than σ describe the motion of the sphere. Deduce an expression for

(i) initial acceleration of the sphere and

(ii) its terminal velocity

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2. (a) Explain Stokes Law

(b) Define terminal velocity

(c) Describe an experiment to determine the terminal velocity

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3. Explain Poiseuille's formula for the volume of liquid flowing through a capillary tube - Describe an experiment to determine the coefficient of viscosity of a liquid by Poiseuiles formula.

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4. State and prove Bernouli's theorem.

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5. Explain the working of a venturimeter, Obtain an expression for the volume of liquid flowing per second through pipe.

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Short Answer Questions

1. Distinguish between thrust and pressure.

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2. What is upthrust or buoyancy?

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3. State Archimedes, principle.

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4. What is drag force? Distinguish between viscous drag and high speed drag,

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5. What is viscosity?

Watch Video Solution

6. Define coefficient of viscosity

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7. State and explain Stokes formula.

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8. Define terminal velocity: A steel ball is dropped in a viscous oil. Draw a simple labelled diagram to show the forces acting on the ball as it falls through the oil.

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9. State Poiseuille's law formula.

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10. Derive Poiseuille's formula using dimensions.

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11. Distinguish between streamline flow and turbulent flow.

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12. What is Reynold's number? Give its significance.

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13. Define critical velocity.

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14. Derive the equation of continuity.

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15. What are the energies possessed by a liquid ?

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16. Show that the pressure energy per unit volume of a liquid is P.

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17. State and prove Bernouli's theorem.

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18. Explain the working of a venturimeter, Obtain an expression for the volume of liquid flowing per second through pipe.

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19. Explain how an aeroplane gets 'lift'.

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20. What is Magnus effect ?

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21. A spinning cricket ball takes a curved path, Explain.

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22. Explain Torricelli's theorem

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23. Explain the working of a Pitot's tube.

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24. What is the use of a filter pump ? How does it work?

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25. What is a Prandtl tube?

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26. Rain drops filling under gravity do not acquire very high velocity. Why?

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27. In a closed room dust generally settles down. Why?

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28. According to Bemoulli's theorem the pressure of water should remain constant in a pipe of uniform radius. But in practice, it goes on decreasing. Why?

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29. Two streamlines cannot cross each other. Why?

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30. What is the effect of temperature on the viscosity of a liquid?

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31. When the water tap is closed with our fingers jets of water gush through the space between fingers with high speed. Why?

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32. Water is taken in one beaker and glycerine in another. Both are stirred well and kept on the table. Which will come to rest first?

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33. Why does a flag flutter when there is wind ?

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34. 'A rifle bullet is cylindrical'. Why?

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35. The upper surface of wings of an aeroplane are made convex and lower concave

downwards?

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36. The snow accumulated on the wings of an aeroplane may decrease the lift " why ?

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Very Short Answer Questions

1. "In scooters more viscous mobile oil is used in summer than in winter". Why?

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2. Why the size of the needle of a syringe controls flow rate better than the thumb pressure exerted by a doctor while administering an injection?

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3. Water flows faster than honey. Why?

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4. What is an ideal liquid ?

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5. Cars and aeroplanes are streamlined. Why?

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6. By blowing air into a funnel through the narrow end, the filter paper inside the funnel cannot be removed. Why?

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7. Why do the machine parts get jammed in winter?

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8. The fire fighters attach brass jets at the end of water pipes. Why?

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Selected Problems From Pressure Archimedes Principle

1. 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 425 cm^(2). What maximum pressure would the small piston have to bear?

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

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3. A tank, with a square base of area $1.0m^2$ is divided by a vertical partition has a small hinged door of aren $20cm^2$. The tank is filled with water in one compartment, and an acid (of relative density 1.7) in the other, both to the height of 4.0 m. Compute the force necessary to keep the door closed

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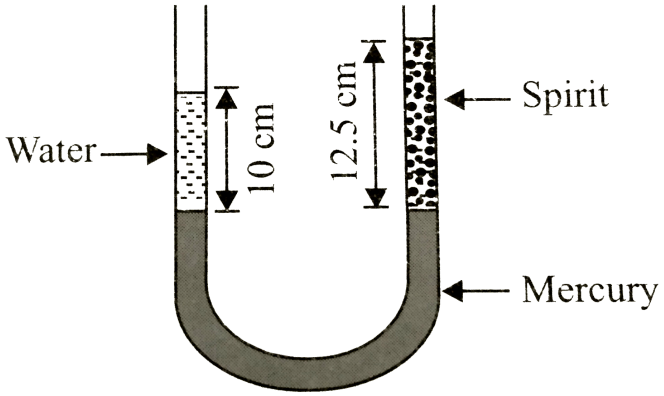
4. A U tube contains water and methylated spirit seperated by mercury .The mercury columns in the two arms at the same level with 10 cm of water in one arm and 12.5 cm of spirit in the order as shown in figure. The relative density of the spirit is



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5. A piece of wood of volume$0.6m^3$ floats in water. Find the volume exposed What force is required to meet completely under water? Density of wood =$800kg/m^3$.

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6. A cube of side 4 cm is just completely immersed in a liquid A. When it is put in a liquid B, it floats with 2 cm outside the liquid.

Calculate the ratio of densities of the two liquids.

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7. An iron block is suspended from a string and is then completely immersed in a container of water. The mass of iron is 1 kg and its density is $7200 kg/m^3$. What is the tension in the string before and after the iron block is immersed ?

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Selected Problems From Viscosity Stokes Law

1. A square plate of 0.1 m side moves parallel to another plate with a velocity of $0.1ms^{-1}$ both plates immersed in water. If the viscous force is 0.02 N and the coefficient of viscosity 0.01 poise, what is the distance apart?

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2. flat plate is separated from a large plate by a layer of glycerine of thickness $3 \times 10^{-3} m$. If the coefficient of viscosity of glycerine is $2Ns/m^2$ what is the force required to keep the plate moving with a velocity of $6 \times 10^{-2} m/s$. Area of the plate is $4.8 \times 10^{-3} m$

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3. Two metal plates of area $2 \times 10^{-4} m^2$ each, are kept in water and one plate is moved over the other with a certain velocity. The distance between the plates is $2 \times 10^{-4} m$. If the horizontal force applied to move the plate is $10^{-3} N$, calculate the velocity of the plate. Given η of water is10^{-3} decapoise.

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4. Aflat plate of area $0.05m^2$ is separated from another large plate at rost by a liquid layer of uniform thickness $1\mu m$. The tangential force needed to move the smaller plate with a constant velocity of $10cms^{-1}$ i s 20 N. Calculate the coefficent of viscosity of the liquid.

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5. A small glass sphere of radius $2x10^{-3}m$is moving through a liquid of viscosity 0.11 decapaise. Calculate the viscos force acting on it if the speed of the ball is $0.05ms^{-1}$

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6. An iron ball of radius 0.3 cm falls through a column of oil of density $0.94gcm^{-3}$ .It is found to attain a terminal velocity of $0.5cms^{-1}$.

Determine the viscosity of the oil. Given that the density of iron is $7.8gcm^{-3}$

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7. An air bubble of diameter 2 cm is allowed to rise through a long cylindrical column of viscous liquid and travels at the rate of $0.21cms^{-1}$. If the density of the liquid is $1.47gcm^{-3}$. find the coefficient of viscosity. Density of air is neglected.

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8. Compute the terminal velocity of a rain drop of radius 0.3 mm. Take coefficient of viscosity of air $1.83X10^{-5}$ poise and density of air = $1.3kgm^{-3}$ Density of water - 10^3kgm^{-3} and $takeg = 9.8ms^{-2}$

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9. In a Millikan's oil drop experiment what is the terminal speed of a drop of radius $2.0 \times 10^{-5}m$, and density $1.2 \times 10^3kgm^{-3}$?.

Take the viscosity of air at the temperature of the experiment to be $1.8 \times 10^{-5} Nsm^{-2}$ How much is the viscous force on the drop at that speed ? Neglect buoyancy of the drop in air.

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10. A glass of radius 10^{-3} and density $2000 kgm^{-3}$ fall in a jar filled with oil of density $800 kgm^{-3}$ .The terminal velocity is found to be 1 cm/s. Calculate the coefficient of viscosity of oil

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11. A steel ball of radius 2×10^{-3}m is released in an oil of viscosity $0.232 Nsm^{-2}$ and density $840 kgm^{-3}$. Calculate the terminal velocity of ball. Take density of steel as $7800 kgm^{-3}$

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12. A gas bubble of diameter 002 m rises steadily at the rate of$2.510^{-2} ms^{-1}$ through a solution of density $2.5 \times 10^{3} kgm^{-3}$. Calculate

the coefficient of viscosity of the solution. Neglect the density of the gas.

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13. A drop of water of radius $10^{-5}m$ is falling through a medium whose density is $1.21kgm^{-3}$ and coefficient of Viscosity 1.8×10^{-4} poise. Find the terminal velocity of the drop.

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14. Determine the radius of a drop of water falling through air, if it covers 0-048 min 4 s with a uniform velocity. Assume the density of air as 0-00121 gm/cc and $\eta = 1.8 \times 10^5 Nsm^{-2}$.

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15. A spherical glass ball of mass 1.34×10^{-4} kg and diameter4.4×10^{-3}m takes 6-4s to fall steadily through a height of 0-381 m inside a

large volume of oil of specific gravity 0.943. Calculate the coefficient of viscosity of oil.

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16. Two equal drops of water are falling through air with a steady volocity of $10cm/s$. If the drops recombine to form a single drop what would be their terminal velocity ?

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17. Emery powder particles are stirred up in a beaker of water 0.1 m deep. Assuming the particles to be spherical and of all sizes, calculate the radius of the largest particle remaining in suspension after 24 hours. Given that density of emery is $4000 kgm^{-3}$ and coefficient of Viscosity water is 0.001 decapoise.

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Selected Problems From Poiseuille S Formula

1. In giving a patient blood transfusion the bottle is set up so that the level of blood is 1.3 m above the needle which has an internal diameter of 0-36 mm, and is 0-03 m in length. If 4-5 ce of blood passes through the needle in one minute calculate the viscosity of blood if density is $1020 kgm^{-3}$

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2. A capillary tube PQ of length 0.6 m and radius $4 \times 10^{-3} m$ is connected in series with another capillary tube QS of length 0.45 m and radius $10^{-3} m$. The tubes are arranged horizontally. End P is connected to a vessel of water having constant pressure head of 0.8 m. The end S is open to the atmosphere. Find the pressure at the junction Q ?

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3. The rate of flow of a liquid through a capillary tube of radius r is under a pressure difference of P. Calculate the rate of flow when the diameter is reduced to half and the pressure difference is made 4 P?

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4. Calculate the mass of alcohol flowing in two minutes through a tube of radius 5×10^{-4} m and length 0.5 m, if there is a constant

pressure head of 0.6 m of alcohol. Density of alcohol is $800kg/m^3$ Coefficient of viscosity of alcohol =$1.38 \times 10^{-3} Ns/m^3$?

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5. A liquid flows through two capillary tube under the same pressure head. The lengths of the tube are in the ratio 2:1 and the ratio of their diameters is 2:3. Compare the rates of flow of liquid through the tubes ?

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6. A capillary tube of length 5 cm and diameter 1 mm is connected to a tank horizontally. The rate of flow of water is 10 ce per minute. Calculate the rate of flow of water through another capillary tube of diameter 2 mm and length 50 cm is connected in series with the first capillary?

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7. Glycerine flows steadily through a horizontal tube of length 1.5m and radius 1.0 cm. If the amount of glycerine collected per second at one end is$4.0 \times 10^{-3} kgs^{-1}$ what is the pressure difference between the two ends of the tube? (Density of glycerine $= 1.3 \times 10^{3} kgm^{-3}$ and coefficient of viscosity of glycerine $= 0.83 Nsm^{-2}$)

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8. An orifice of diameter 8 mm is made on one side of a tank in which water level is 10 mm above the orifice. What is the rate of discharge of water through the orifice?

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9. Water flows through a hose (pipe) whose internal diameter is 2 cm at a speed of 1 m/s. What should be the diameter of the nozzle if the water is to emerge at a speed of 4 m/s

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10. Calculate the speed of efflux of kerosene oil from an orifice of a tank in which pressure is 4 atmosphere. Density of kerosene oil = 0.72 kg /lite.

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11. The reading of pressure meter attached with a closed water pipe is $3.5 \times 10^5 Nm^{-2}$. On opening the valve of the pipe, the reading

of pressure meter is reduced to $3 \times 10^5 Nm^{-2}$. Calculate the speed of water flowing out of the pipe.

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12. Water is maintained at a height of 10 min a tank. Calculate the diameter of orifice needed at the base of the tank to discharge water at the rate of $26.4m^3$ per minute.

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13. The cylindrical tube of a spray pump has a cross-section of $8cm^2$. one end of which has 40 fine holes each of diameter 10 mm. If the liquid flow inside the tube is 0.15 m per minute, what is the speed of ejection of the liquid through the holes ?

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14. At what speed will the velocity of a stream of water be equal to 20 cm of mercury

column?

(Taking, g =10 ms^{-2})

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15. In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are $70ms^{-1}$ and $63ms^{-1}$ respectively. What is the lift on the wing if its area is$2.5m^2$? Take the density of air to be$1.3kgm^{-3}$

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16. A wide tank is filled with water and kerosene. The tank has a small hole at the bottom. The height of water layer is 40 cm and that of the kerosene layer is 30 cm. Find the velocity of the water flow, neglecting the viscosity in question. Given relative density of kerosene is 0.80.

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17. The diameter of a pipe at two points where a venturimeter is connected is 5 cm and 8 cm and the difference of level in it is 4 cm. Calculate the mass of water flowing through the pipe per second.

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18. A large storage tank is filled to a height h_1. There is a hole at the height h_2 from the

bottom of the tank as shown in Fig How for from the tank will the stran land ?

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19. The cross-section area of the pipe shown in Fig. is $50cm^2$ at the wider portions and $20cm^2$ at the constriction. The rate of flow of water through the pipe is $4000cm^3/s$. Find ,

(i) the velocities at the wide and the narrow portions

(ii) the pressure difference between these portions

(iii) the difference in height between the mercury columns in the U-tube.

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