PHYSICS

BOOKS - MODERN PUBLICATION

Viscosity

Example

1. A plate of metal 100 cm in area rests on a layer of castor oil 2 mm thick, whose coefficient of viscosity is 15.5 poise. Calculate

the horizontal force.nrequired to move the plate with a uniform speed of $3cms^{-2}$

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2. A capillary tube of 1 mm in diameter and 20 cm in length is fitted horizontally to a vessel kept full of alcohol. The depth of the centre of the capillary tube below the surface of alcohol is 20 cm. If the viscosity and density of alcohol are 0.012cgs unit and $0.8gcm^{-3}$ respectively,

find the amount of the alcohol that will flow out in 5 minutes. Given that g =$980 cm s^{-2}$

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3. An iron ball of radius 0.3 cm falls through oil of density $0.94 g cm^{-3}$. It attains a terminal velocity of 0.5 cm s^{-1}. Determine the viscosity of the oil. Given density of iron = 7.8 g cm^{-3}

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4. A force of 160 dyne is required to move a metal plate having an area of $0.02m^2$ with a constant speed of $5cms^{-1}$ over a liquid film 1 mm thick. Find the coefficient of viscosity of the liquid.

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5. A square plate of 10 cm side moves parallel to another plate with a velocity of $10cms^{-1}$, both plates immersed in water. If the viscous

force is 200 dyne and viscosity of water is 0.01 poise, what is their distance apart?

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6. Check the dimensional consistency of the poiseuille's formula for the laminar flow in a tube: V=(piR^(4)(p_1-p_2))/(8etal) for laminar flow in a tube, where the symbols V, r, $(p_1 - p_2)$ and I are respectively volume of liquid flowing per second, radius of the tube,

pressure difference, coefficient of viscosity and length of the tube.

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7. The radius of a pipe carrying a liquid gets decreased by 5% because of deposits on the inner surface. By how much would the pressure difference between the ends of the constricted pipe have to be increased to maintain a constant flow rate?

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8. An engineer wants to have the same flow rate of water and light machine oil from the pipes of the same length and with the same pressure head. What should be ratio of the radii of the two pipes? Given that viscosity of water- 0.01 poise and that of light machine oil- 11 poise.

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9. In a hospital, a patient receives a $500cm^3$ blood transfusion through a needle with a length of 5 cm and inner radius of 0.03 cm. If the blood bag is kept 85 cm above the needle, how long the transfusion takes place? Given that the viscosity of blood is 0.017 poise and the density of blood is $1.02gcm^{-3}$

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10. In giving a patient a 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 3 cm in length . If $4.5cm^3$ of blood passes through the meedle in one minute, calculate the viscosity of blood. The density of blood is $1050kgm^{-3}$.

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11. In Millikan's oil drop experiment, what is the terminal speed of an uncharged drop of radius 2.0×10^5 m and density $1.2 \times 10^3 kgm^{-3}$. Take the viscosity of air at the temperature of the experiment to be 1.8×10^{-5} Pa s. How much is the viscous force on the drop at that speed ? Neglect buoyancy of the drop due to air

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12. Eight rain drops of radius 1 mm each falling downwards with a terminal velocity of Sems coalesce to form a bigger drop. Find the terminal velocity of the bigger drop.

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13. With what terminal velocity will an air bubble 0.8 m in diameter rise in a liquid of viscosity 0.15 Ns m^-2` and specific gravity 0.9 ?

What is the terminal velocity fo the sam ebubble in water?

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14. An oil drop falls through air with a terminal velocity of $5 \times 10^{-4} ms^{-1}$ Calculate the radius of the drop. Viscosity of air- $1.8x10^{-5} Nsm^{-2}$, density of oil =$900 kgm^{-3}$ Neglect density of air as compared to that of the oil.

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15. An oil drop falls through air with a terminal velocity of $5 \times 10^{-4} ms^{-1}$ Calculate the terminal velocity of a drop of half of this radius. Viscosity of air-$1.8x10^{-5} Nsm^{-2}$, density of oil =$800 kgm^{-3}$ Neglect density of air as compared to that of the oil.

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16. Why is that a liquid set in motion comes to rest after some time?

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17. Two flasks, one containing water and other glycerine, are stirred rapidly and kept on the table. Which liquid will come to rest earlier than the other?

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18. If honey and water are dropped out of a tube seperately the honeycomes out later

than water.Why?

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19. The velocity of water in a river is less on the bank and large in the middle. Explain, why.

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20. When water flows through a pipe, which layer moves fastest?

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21. Why is it that we need a constant driving force for maintenance of the flow of oil through pipe-lines in oil refineries?

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22. What is Sl unit of viscosity?

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23. Define one decapoise.

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24. Give relationship between poise and decapoise.

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25. The dimensions of viscosity is same as those of the product of pressure and time. Is

this correct?

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26. Hotter liquids flow faster than cold liquids. Why?

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27. Why machines are sometimes jammed in winter?

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28. Why high viscosity liquids are used buffers in trains?

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29. In which liquid, the terminal velocity of an object will have lesser value-water or honey?

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30. What is viscosity and coefficient of viscosity?

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31. What is difference between friction and the viscosity?

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32. Why does an object entering the earth's amosphere at high velocity catch fire?

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33. Lubricant oil used in machines should be of high vescosity.Why?

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34. Why oils of different viscosities are used in automobiles in different seasons?

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35. Two capillaries of same length but radii in the ratio 1: 2 are connected in series and a liquid flows through this system under streamline conditions. if the pressure across the two extreme ends of the combination of

cube is 1 metre of water column what is a pressure difference across the first tube?

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36. As soon as parachute of a falling soldier opens,his acceleration decreases and soon becomes zero. Why?

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37. Explain, why a parachute is invariably used, while jumping from an aeroplane.

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38. A bigger rain drop falls faster than a smaller one. Why ?

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39. The radius of ball A is twice of than of ball B.What wll be ratio of their terminal velocities in water?

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40. What is the weight of a body, when it falls with terminal velocity through a viscous medium?

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41. What is the terminal velocity in a horizontal direction for any object thrown through air?

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42. What do you expect to happen to any object thrown downward at a velocity greater than its terminal velocity?

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43. Explain, why rain drops falling under gravity do not acquire very high velocity.

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44. Dust generally settles down in a closed room. Explain.

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45. Why do the clouds seem floating in the sky ?

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46. What is terminal velocity?

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47. Why small air bubbles rises slowly through the liquid whereas the bigger one rises rapidly?

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48. What are practical applications of Stokes law?

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49. What is the weight of a body, when it falls with terminal velocity through a viscous medium?

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50. 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 (considered massless and frictionless) as in fig.A liquid with a film thickness of 0.30 mm is placed between the block and the table.When released,the block moves ot the right with a constant speed of $00.085ms^{-1}$.Find the coefficient of viscosity of the liquid.

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51. In an experiment with Poiseuille's apparatus, the following figures were observed. Volume of liquid collected per minute $15cm^3$ head of liquid-30cm, length of tube-25 cm, diameter of tube 0.2cm density of liquid $2.3gcm^{-3}$ Find the coefficient of visocity.

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52. A liquid flows through a pipe of 1.0 mm radius and 10 cm length under a pressure of

$10^4 dy \neq cm^{-2}$. Calculate the rate of flow and the speed of the liquid coming out of the tube The coefficient of viscosity of the liquid is 1.25 centipoise.

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53. A drop of water of diameter 0.02 mm is falling through a medium, whose density is $1.21 \times 10^3 kgm^{-3}$ and coefficient of viscosity is 1.8×10^{-9} poise. Find the terminal velocity of the drop.

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54. Find the terminal velocity of a steel ball 2 mm in diameter falling through glycerine. Given that specific gravity of steel- 8, specific gravity of glycerine-1.3, viscosity of glycerine -3.3 poise

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55. A ball bearing of radius 1.5 mm made of iron of density $7.85 gcm^{-3}$ is allowed to fall

through a long column of glycerine of density $1.25 gcm^{-3}$ It is found to attain a terminal velocity of $2.25 cms^{-1}$ Determine the viscosity of glycerine in centipoise.

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Exercise

1. Explain the term viscosity.

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2. Dimensional formula for the coefficient of viscosity is :

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3. What is viscosity and coefficient of viscosity?

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4. What are the various factors on which the flow of liquid through a narrow tube depend.

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5. What is terminal velocity?

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6. Define terminal velocity and find an expression for it.

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7. What is the difference between viscosity and friction? Derive the expression for the terminal velocity of a sphere falling through a viscous fluid.

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8. What is Stokes' law? Derive the relation by method of dimensions.

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9. Why small air bubbles rises slowly through the liquid whereas the bigger one rises rapidly?

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10. What is viscosity and coefficient of viscosity?

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11. What is the difference between viscosity and friction? Derive the expression for the terminal velocity of a sphere falling through a viscous fluid.

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12. Define coefficient of viscosity. Give its unit.

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13. Define terminal velocity and find an expression for it.

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14. What is the difference between viscosity and friction? Derive the expression for the terminal velocity of a sphere falling through a viscous fluid.

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15. An air bubble of 1 cm radius is rising at a steady rate of $0.5 cm s^{-1}$ through a liquid of density $0.81 g cm^{-3}$. Calculate the coefficient of viscosity of the liquid. The density of air may be neglected.

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16. Determine the radius of a drop of water falling through air, if it covers 4.1 cm in 4 seconds with a uniform velocity. Assume

density of air is $0.001293 gcm^{-3}$ and η for air is 1.8×10^{-4} poise.

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17. Two capillary tubes of lengths 15 cm and 5 cm and radii 0.06 cm and 0.02 cm repectively are connected in series. If the pressure difference across the end faces is equal to pressure of 15cm high water column, then find the pressure difference across the first tube.

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18. Two capillary tubes of lengths 15 cm and 5 cm and radii 0.06 cm and 0.02 cm repectively are connected in series. If the pressure difference across the end faces is equal to pressure of 15cm high water column, then find the pressure difference across the second tube

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19. Two capillary tubes AB and BC are joined end to end at point B. AB is 16 cm long and of diameter 4 mm. BC is 4 cm long and of diameter 2 mm. The composite tube is held horizontally as in Poiseuille's experiment with A connected to a vessel of water giving a constant head of 3 cm and C is open to air. Calculate pressure difference between B and C

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20. Show that if two capillaries if radii r_(1)and r_(2) having lenths l_(1)and l_(2) respectively are set in series ,the rate of flow Q is given by $Q = \frac{\pi p}{8\eta\left[l_1 / r_1^4 + l_2 / r_2^4\right]'}$ where p is the pressure difference across the arrangement and eta is the cofficient of viscosity of the liquid.

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21. The rate of flow of the liquid through the tube of length l and radius r, connected across a perssure head h be V. If two tubes of the same length but of radius r and r/2 are connected in series, across the same pressure head h, find the rate of flow of liquid through the combination.

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22. The rate of flow of the liquid through the tube of length l and radius r, connected across a perssure head h be V. If two tubes of the same length but of radius r and r/2 are connected in parallel, across the same pressure head h, find the rate of flow of liquid through the combination.

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23. Three capillaries of length L, (L/2) and (L/3) are connected in a series. Their radii are r, (r/2) and (r/3) respectively. If a streamlined flow is to be maintained and pressure difference across the first capillary is ρ, then the pressure difference across the second capillary will be

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24. The level of liquid in a cylindrical vessel is kept constant at 30cm. It has three identical

horizontal tubes A, B and C of length 40 cm each coming out at heights 0, 5 and 10 cm respectively. Calculate the length of a single overflow tube of the same radius as that of identical tubes which can replace the three when placed horizontally at the bottom of the cylinder.

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25. 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 of water is 0.001 decapoise

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26. Two equal drops of water are falling through air with a steady velocity of $10 cms^{-1}$

If drops recombine to form a single drop , what will be new terminal velocity ?

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