PHYSICS

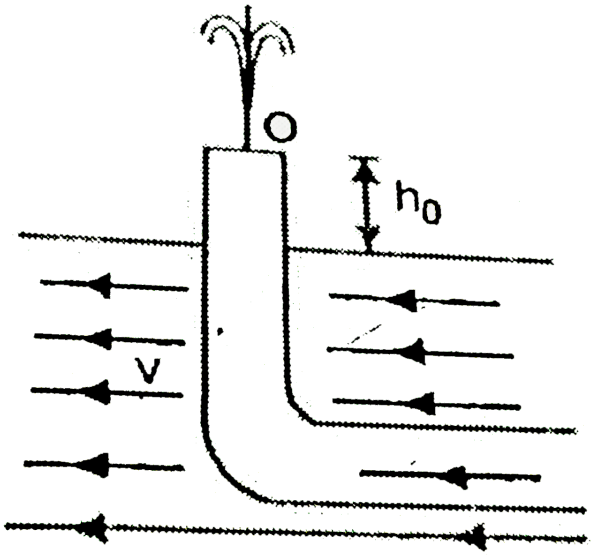
BOOKS - BHARATI BHAWAN PHYSICS (HINGLISH)

HYDRODYNAMICS

Example

1. A bent tube is lowered into a stream of water as shown in the figure. The velocity of the stream is $v = 2m/s$. The closed upper end of the tube is at a

height $h_0 = 10cm$ from the suface of water in the stream and has a small orifice. To what height will the water jet from the orifice spurt?



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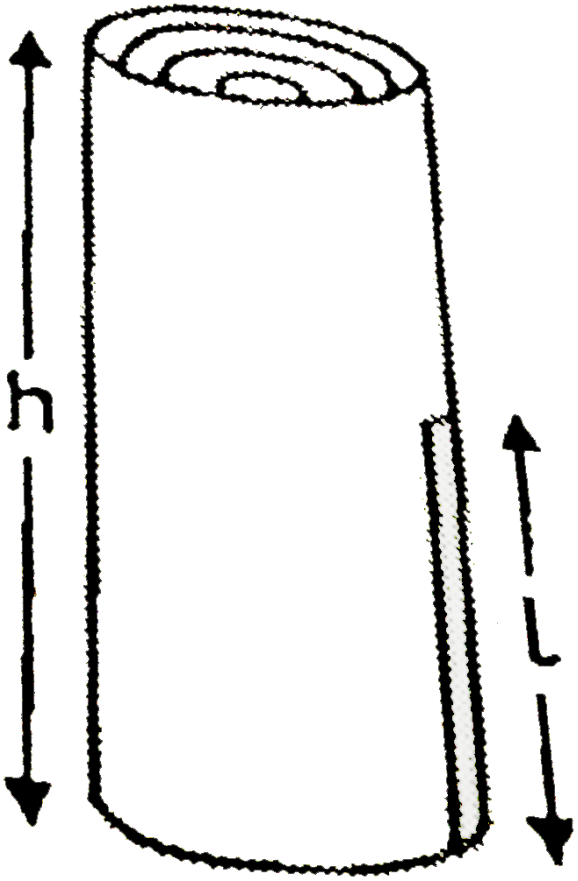
2. A cylinder of height h = 1 m has a narrow vertical slit along its wall running up to a length l = 40 cm

from the bottom. The width of the slit b = 1 mm. The cylinder is filled with water with the slit closed. Find the force experienced by the vessel immediately after then slit is opened?



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3. A lead sphere of density $\rho = 11.3 \times 10^3 \mathrm{kg\,m^{-3}}$ is steadily in glycerine $\left(\rho' = 1260 \mathrm{kg\,m^{-3}}\right.$ and $\eta = 1.4 \mathrm{N\,s\,m^{-2}}.\left.\right)$ What is the maximum diameter of the sphere till which the flow around the sphere remains laminar? It is given that transition to turbulent flow corresponds to Reynolds number Re = 0.5.

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Exercises

1. TheThe velocity of flow of water in the main water supply pipe is $1.0ms^{-1}$. What is the velocity in the deliverty pipe if area of cross-section of the supply pipe is 16 times that of the delivery pipe?

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2. Calculate the velocity of efflux of kerosene form a tank in which the pressure is $4 \times 10^5 \mathrm{N\ m^{-2}}$ above the atmospheric pressure. The density of kerosene is 800 $\mathrm{kg\ m^{-3}}$

[Hint: $v = \sqrt{2gh}$]

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3. The reading of pressure meter attached with a closed pipe is $3.5 \times 10^5 Nm^{-2}$. On opening the value of the pipe, the reading of the pressure meter is reduced to $3.0 \times 10^5 Nm^{-2}$. Calculate the speed of the water flowing in the pipe.

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4. A metel plate 100 sq cm in area rests on a 2-mm layer of castor oil, whose coefficient of viscosity is 1.55 SI units. Calculate the horizontal force required to move the plate with a speed of 3 cm per

second.

[Hint:

$F = -\eta A \frac{dv}{dx}$. Here $\frac{dv}{dx} = \frac{3 \times 10^{-2} ms^{-1}}{2 \times 10^{-3}} = 15 s^{-1}$

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5. Calculate the critical velocity of water through a narrow tube of radius 0.3 mm. Coefficient of viscosity of water is 0.0011 SI units and density of water 1000kg m^{-3}. Take Reynolds number as 1000.

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6. Water is conveyed through a tube 8 cm in diameter and 4 km in length at the rate of 120 litres per minute. Calcualte the pressure difference required to maintain the flow. Coefficient of viscosity of water = 0.001 SI units.

[Hint" "$V = \frac{\pi P r^4}{8\eta l}$]

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7. Find the terminal velocity acquired by a steel ball of diameter 3.2 mm falling under gravity through an oil of density 920 $\mathrm{kg\,m^{-3}}$ and viscosity

$1.64\mathrm{N\ s\ m}^{-2}$. The density of steel may be taken as 7820 kg m^{-3}.

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8. A steel ball-bearing of diameter 3 mm falls through glycerine and covers a distance of 25 cm in 10 sec. The specific gravity of steel and glycerine are 7.8 and 1.26 respectively. What is the viscosity of glycerine. Density of water = 1000 kg m^{-3}.

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9. An air bubble of radius 1 cm is found to rise in a cylindrical vessel of large radius at a steady rate of 0.2 cm per second. If the density of the liquid is 1470 kg m^{-3}, find its viscosity. Take $g = 9.8ms^{-2}$

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10. Calculate the velocity with which rain drops reach us if the diameter of rain drops is 1 mm and viscosity of air 18×10^{-6} SI units.

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11. A bubble of air of 2 mm diameter rises in a liquid of viscosity 0.075 SI unit and density 1350 kg per cubic metre. Findthe terminal velocity of the bubble.

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12. A vessel fitted with a horizontal capillary tube near its bottom is alternately filled with two liquids of specific gravity 0.8 and 0.9. It empties itself in 40 and 30 minutes respectively. Calculate the ratio of their coefficient of viscosity.

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13. A vessel of cross-section 20×10^{-4} square metres has a capillary tube of length 10 cm and internal radius 0.5 mm at the bottom. It is initially filled with water to a height of 20 cm above the capillary tube. Find the time taken by the vessel to expt one-half of its contents, given that the viscosity of water of 0.001 SI units. Density of water = 1000 kg per cubic metre.

[Hint : See example 5]

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14. A tank is filled with water to a height H. A hole is punched in the wall at a depth h below the water surface. Find the distance x from the wall at which the stream strikes the floor. Could a hole be punched at another depth so that this second stream would have the same range? If so at what depth? For what value of h is range maximum?

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15. In a horizontal oil pipeline of constant cross-sectional area the pressure decrease between two point 300 km apart is 5000 pascal (1 pascal = 1

newton per square meter). What is the loss of energy per unit volume per unit distance?

[Hint : Loss in energy $= \frac{P_1}{\rho} - \frac{P_2}{\rho}$ because $\frac{P}{\rho}$ is pressure energy per unit mass and loss in energy per unti volume $= P_1 - P_2$.]

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16. A cylindrical vessel of hieght h and base area S is filled with water. An orifice of area $s << S$ is made at the bottom of the vessel. Neglection viscosity find how soon the vessel would be emptied.

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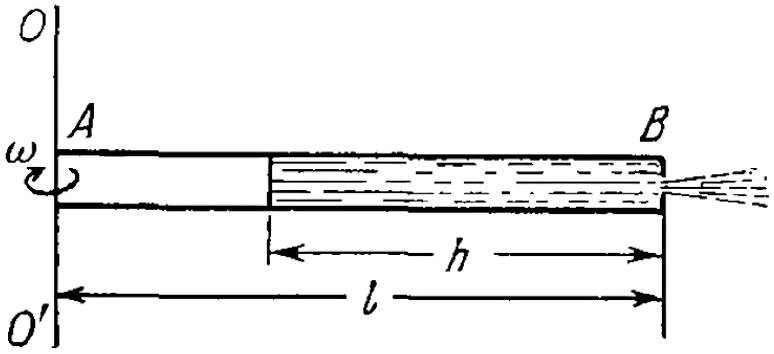
17. A horizontally oriented tube AB of length l rotates with a constant angular velocity ω about a stationary vertical axis OO' passing through the end A (figure). The tube is filled with an ideal fluid. The end A of the tube is open, the closed end B has a very small orifice. Find the velocity of the fluid relative to the tube as a function of the column

"height" h.



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18. A horizontal cylindrical vessel with a small orifice of area s is first filled with a liquid of density ρ and

then forced out through it by applying a constant force on the piston closing the cylinder. The time taken is t. The time taken is t. Calculate the work done.

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19. Water flows out of a big tank along a horizontal tube of length l and radius r and bent at right angles at the other end. The rate of flow is Q. Calculate the moment of the force exerted by the water on the tube about the other end. Neglect viscosity of water.

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