Fluid Mechanics

Assignment-6 (Bernoulli's Equation)

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1. Consider the flow through a tube as shown in the figure. In this flow a bent glass tube is inserted. Additionally there is a static pressure tap on the side wall away from the position where the bent tube is inserted. The glass tube fills up with water and reaches a certain height (much like a manometer). The difference in the water level between the static tap and bent tube is h. The velocity at the entrance of the tube goes to zero in a reversible adiabatic maner. Find out the pressure at the entrance of the tube in terms of h.

   The pressure measured in this case is known as the **Stagnation Pressure**. The key assumption behind the pressure being measured to be the stagnation pressure is that the velocity must reversibly go to zero (stagnation velocity is zero). For any other process, the pressure will be different.

   The pressure at the static tap is called as the static pressure and measures the piezometric pressure.

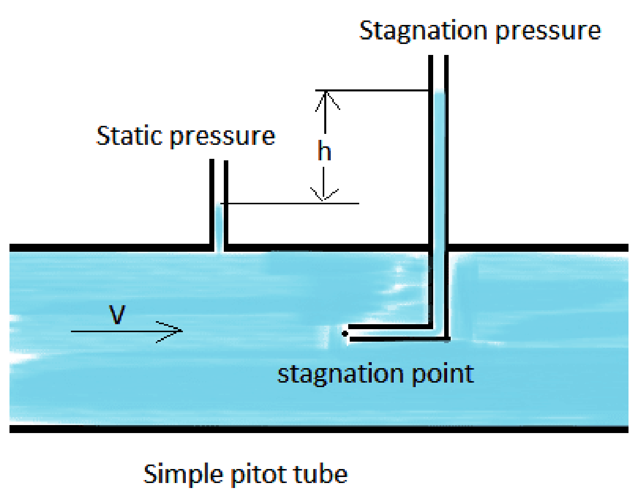


Figure Q: Streamlines

5+5=10

2. See the demonstration of an inviscid, steady, constant density flow-field below.

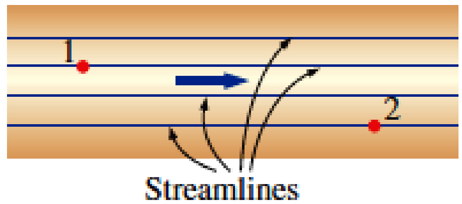


Figure Q: Streamlines

Which among the below statements is correct regarding the application of Bernoullis equation in this case?

(a) One cannot apply Bernoullis equation between points 1 and 2 since they are not on the same streamline.

(b) One can apply Bernoullis equation between points 1 and 2 when the flow is irrotational, even though the points are on different streamlines.

(c) Both (a) and (b) are wrong.

(d) None of the above.

Marks: 10

3. During a trip to the beach ($P_{\text{atm}} = 1\,\text{atm} = 101.3\,\text{kPa}$), a car runs out of gasoline, and it becomes necessary to siphon gas out of the car of a Good Samaritan (see the figure below).

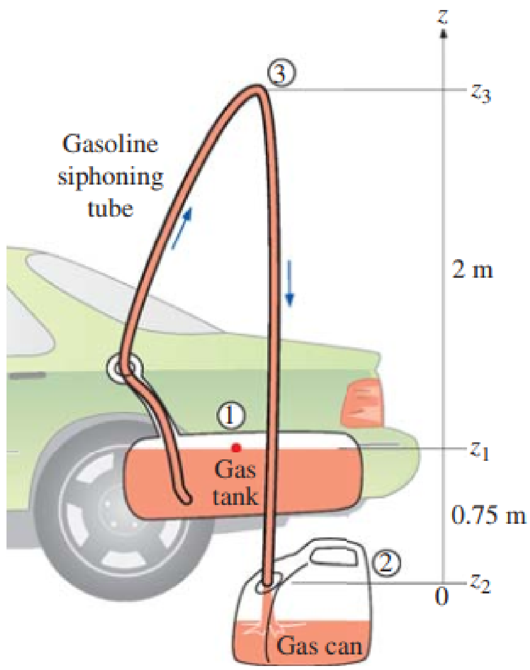
The siphon is a small-diameter hose, and to start the siphon it is necessary to insert one siphon end in the full gas tank, fill the hose with gasoline via suction, and then place the other end in a gas can below the level of the gas tank.

The difference in pressure between point 1 (at the free surface of the gasoline in the tank) and point 2 (at the outlet of the tube) causes the liquid to flow from the higher to the lower elevation. Point 2 is located 0.75 m below point 1 in this case, and point 3 is located 2 m above point 1. The siphon diameter is 5 mm, and frictional losses in the siphon are to be disregarded. Determine

(a) the minimum time to withdraw 4 L of gasoline from the tank to the can and

(b) the pressure at point 3. The density of gasoline is $750\,\text{kg/m}^3$.

(c) How the phenomenon of '*cavitation*' can limit the performance of a siphon?



Marks: 2.5+2.5+5=10

4. Someone proposes siphoning cold water over a 7-m-high wall. It is known that at sea level, vapour pressure of cold water becomes equal to 1 atmosphere.

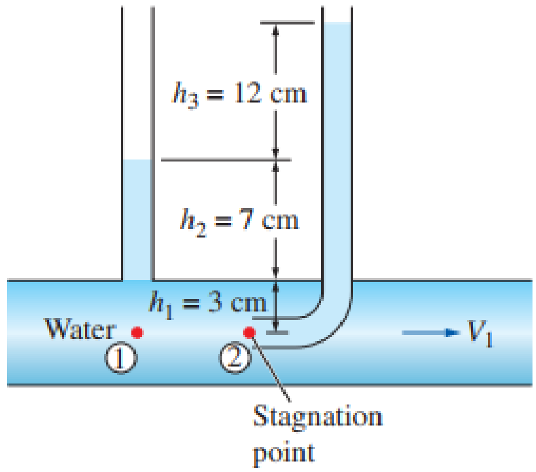
   Do you expect the siphon to work properly in ideal conditions? What major factors can influence its smooth operation in practice?

Marks: 5+5=10

5. In a certain application, a siphon must go over a high wall. Can water or oil with a specific gravity of 0.8 go over a higher wall? Explain for the cases when (a) the frictional effects are not considered, and (b) frictional effects are accounted for.

Marks: 10

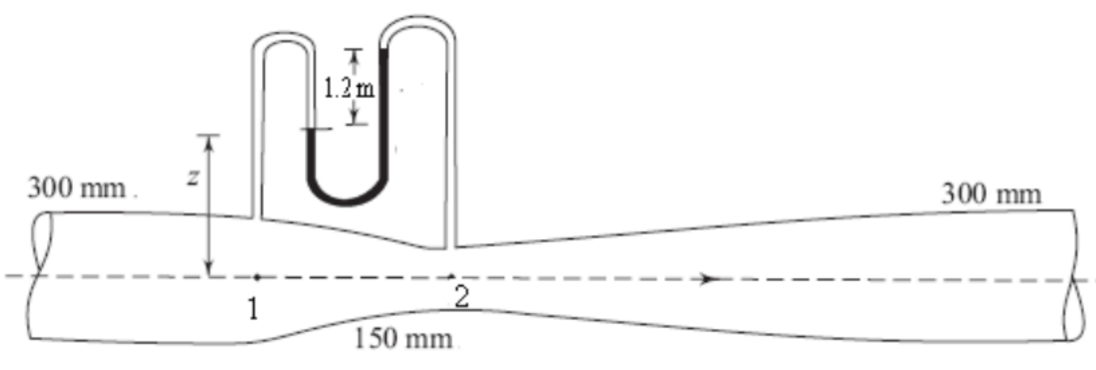
6. A piezometer and a Pitot tube are tapped into a horizontal water pipe, as shown in figure, to measure static and stagnation (static + dynamic) pressures. For the indicated water column heights, determine the velocity at the center of the pipe.



Marks: 10

7. Water flows through a 300 mm × 150 mm horizontal venturimeter at the rate of 0.065 m^3/s and the differential gauge is deflected 1.2 m, as shown in the figure below. Measured values of Δh, the difference in piezometric pressures between sections 1 and 2, for a real fluid will always be greater than that assumed in case of an ideal fluid because of the frictional losses in addition to the change in momentum. Therefore, the application of Bernoulli's equation along with the flow continuity principle overestimates the actual flow rate. In order to take this into account, a multiplying factor C_d, termed as the coefficient of discharge is incorporated to express the actual flow rate.

   Given that the specific gravity of the manometric liquid is 1.6, determine the coefficient of discharge of the venturimeter.



Marks: 10

8. Define

   (a) coefficient of velocity,

   (b) coefficient of contraction,

   and (c) vena-contracta in relation to flows through orifices and mouthpieces.

   Marks: 2.5+2.5+5=10

9. An orifice meter with orifice diameter 10 cm is inserted in a pipe of 20 cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter gives readings of $19.62\,\mathrm{N/cm^2}$ and $9.81\,\mathrm{N/cm^2}$, respectively. Co-efficient of discharge for the meter is given as 0.6. Find the discharge of water through pipe in litres/s.

   Marks: 10