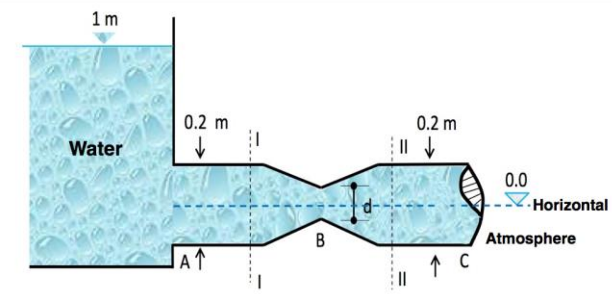
Question 1: There exists an incompressible, ideal and permanent (steady) flow of water in the reservoir-pipe system as shown in the figure given below. Water is poured into the atmosphere from a horizontal pipe ABC. Taking the absolute atmospheric pressure as 9.81 N/cm^2 and absolute vapor pressure as 0.23 N/cm^2:

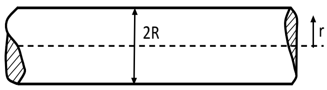
- a- Calculate the discharge of the system.
- b- Without changing the discharge and letting the water evaporate, find the possible minimum value for the diameter of pipe B.
- c- Draw the hydraulic and energy grade lines of the system.
- d- Find the force that flow exerts on the narrowing and expanding sections of the pipe choosing the control volume between cross-sections (I-I) and (II-II).



Answer : Q=0.1392 m^3/s; d_{min}=0.11 m

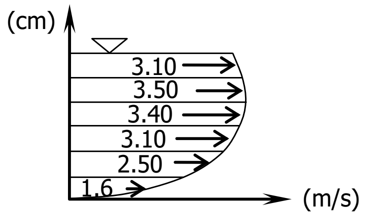
Question 2: The velocity distribution on the cross-section of a pipe of 10 cm diameter is given in metric units as

$U = 400\left(R^2 - r^2\right)$. Find the maximum velocity on the axis, discharge of the pipe and average velocity in the pipe.



Answer: $U_{max} = 4\, m/s\, ; Q = 0{,}0628\, m^3/s\, ;\, V_{avg} = 2\, m/s$

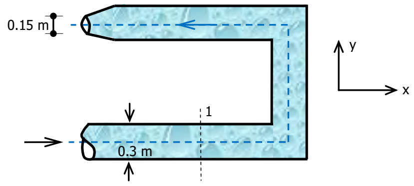
Question 3: Horizontal velocity measurements made by a pitot tube along a vertical line in the mid-sections of a wide channel is shown below. Calculate the channel's discharge per unit width and its average discharge.



Answer : V_o=2.87 m/s

Question 4: A water jet flowing through a horizontal elbow shown in the figure below is poured into the atmosphere. Average flow velocity at cross-section (1) is v_1=2 m/s and gage pressure is p_1=19.62 N/cm^2. With the assumptions of ideal and incompressible fluid and taking absolute atmospheric 9.81 N/cm^2,

- a- Find the energy loss at the elbow.
- b- Find the x,y components of the force that flow exerts on the elbow.



Answer: a- $h_k = 6.98\ m$ b- $R_x = 8.35\ kN;\quad R_y = 0$

Question 5: Velocity components of an ideal and incompressible fluid in a two-dimensional flow (2D) is given as $u = -2\,a\,x\,,\quad v = -2\,a\,y\,.$ (a=constant).

- a- Is such a flow physically possible?
- b- Is there a velocity potential for this function? If so, find out the velocity potential function.
- c- Find the stream function for this flow.
- d- For a=1, find the resultant velocity and acceleration and their components at point M(1,1).

Question 6: Velocity components for a two-dimensional (2D) incompressible flow on the (x-y) plane is given as $u = -x,\quad v = y\,.$

- a- Find the stream function for this flow.
- b- Is there a velocity potential for this function? If so, find out the velocity potential function.
- c- For this flow, find the discharge per unit width that passes from a line or a curvature which connects the points A(-1,1) and B(-2,3).

Question 7: The stream function for a two-dimensional (2D) ideal and incompressible flow is given as $\Psi = -2\,a\,x\,y$

- a- Is such a flow physically possible?
- b- Is there a velocity potential for this function ? If so, find out the velocity potential function.
- c- For a=1, find the resultant velocity and acceleration and their components at point N(1,1).
- d- Draw the flow net.

Question 8: A two-dimensional (2D) flow is given with components $u = 4\,y\,,\quad v = 4\,x\,.$

- a- Draw the streamlines of this flow.
- b- Calculate the acceleration components at point x=1, y=1.
- c- Find the stream function and the potential function of this flow (if there is one).

Question 9: Velocity components of an incompressible liquid are as follows.

$$u = k\,x\,(y+z)\quad,\quad v = k\,y\,(x+z)\quad,\quad w = -k\,z\,(x+y) - z^2$$

- a- What should be the "k" for the given velocity field to correspond to a possible velocity field of a fluid?
- b- Is the flow steady (permanent)? Why?
- c- Is the flow uniform? Why?
- d- Is the flow rotational? Why?
- e- Calculate the components of the rotation vector at point (1, -1, 1).

Question 10: If the vertical velocity component of a two-dimensional water jet hitting a horizontal plate is proportional to the distance to the plate, find the stream function that defines the flow field.

Question 11: The velocity field of an incompressible fluid in a planar flow is:

$u = 3x^2 - 3y^2$ and $v = -6\,x\,y$

a- Show the flow is irrotational.

b- Write the resultant acceleration and their components at point M(x,y).Find the resultant acceleration at point A(1,1).

Question 12: The velocity field of a two-dimensional (2D) flow is given as:

$u = \left(2\,x\,y + t^2\right)$, $v = \left(x^2 - y^2 + 10t\right)$

a- Is such a flow physically possible?

b- Is the flow steady (permanent)?

c- Is there a velocity potential for this function? If so, find out the velocity potential function.

d- Find the stream function of this flow.

e- In this flow field, find the resultant velocity and acceleration and their components at point A(1,1) at time t=1.

Question 13: The velocity components of an ideal fluid in a two-dimensional (2D) flow is given as:

$u = 16\,y - 12\,x$, $v = 12\,y - 9\,x$

For this flow:

a- Show if the flow steady (permanent) or not?

b- Determine whther such a flow is physically possible or not.

c- Examine whether a velocity potential exists or not?

d- Find the stream function and find the equation of a streamline that passes through the point which has coordinates x=1, y=2.

e- Is it possible to determine the equation of equi-potential lines? Explain why?

f- Explain where the Bernoulli equation is valid for this flow.