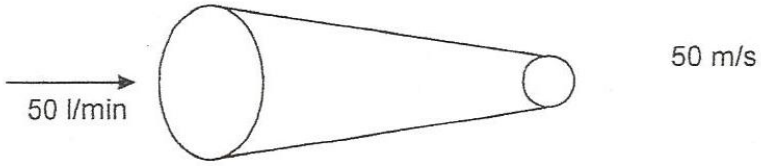
Sample: Mechanics Kinematics Dynamics - Hydromechanics Queries

1. Solve. Calculate the exit diameter of the pressure washer nozzle shown . If the required exit velocity of the water is 50 m/s when the flow rate is 50 litres/ min.



Requires the diameter to be produced as per the given formula (circled). Could you please provide the answer.

Solution.

$$Flow\ rate: \quad = 50\frac{l}{min} = \frac{50 \cdot 10^{-3}}{60}\frac{m^3}{s} = \frac{5}{6} \cdot 10^{-3}\frac{m^3}{s}$$

$$Exit\ velocity: V = 50\ m/s$$

So the cross sectional area (c.s.a.) is flow rate divided by velocity.

$$A = \frac{}{V} = \frac{\frac{5}{6} \cdot 10^{-3}\frac{m^3}{s}}{50\frac{m}{s}} = \frac{1}{6} \cdot 10^{-4} m^2 = 0.167 s m^2$$

In this case, the cross sectional area is the area of the circle:

$$A_{circle} = \pi R^2 = \frac{\pi d^2}{4}$$

where d – diameter of the c.s.a.

Thus,

$$d^2 = \frac{4A}{\pi}$$

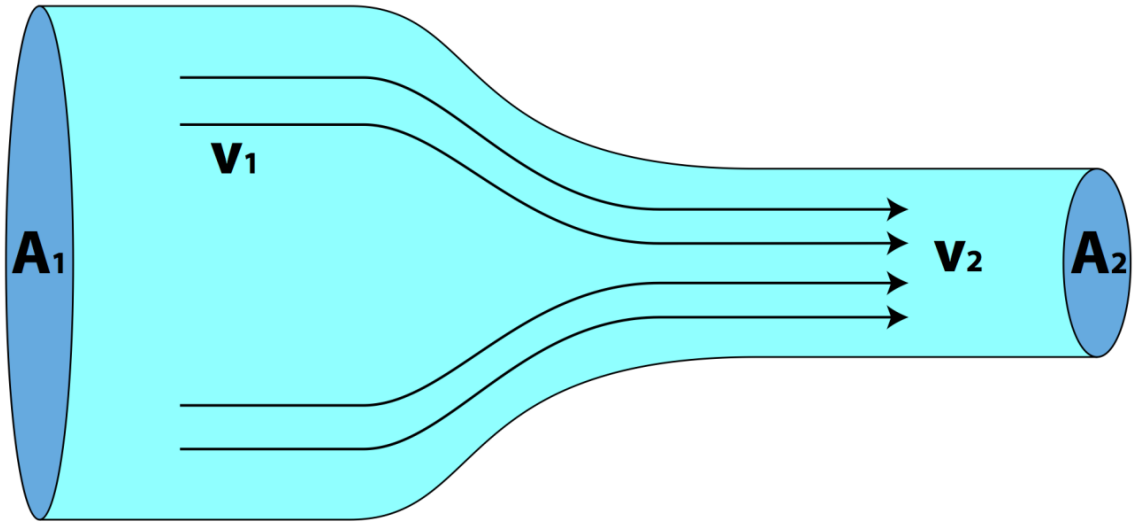
$$d = 2\sqrt{\frac{A}{\pi}} = 2\sqrt{\frac{0.167 \cdot 10^{-4}}{3.14}} = 2 \cdot 0.23 \cdot 10^{-2} = 0.0046\ m = 4.6\ mm$$

Answer: $d = 4.6\ mm$

2. Solve. In a wind tunnel the air passes through a converging duct prior to the working section. The air velocity entering the converging duct is 30ms-1 and the duct has a cross-sectional area 0.25m2 . If the speed of flow in the working section is to be 84ms-1, calculate the csa of the working section. Assume air density is constant at 1.225 kgm-3. Also determine the mass flow of air passing through the wind tunnel.

Would appear to have a difference of opinion concerning the value of A^2 and the formula used to arrive at the value. Could you please clarify and provide the value of A^2 using the formula provided (circled).

Solution.



To solve this problem we should use **continuity equation**:

$$A_1V_1 = A_2V_2$$

where

$$duct\ cross\ sectional\ area: A_1 = 0.25\ m^2$$

$$air\ velocity: V_1 = 30\frac{m}{s}$$

$$speed\ of\ the\ flow: V_2 = 84\frac{m}{s}$$

From the continuity equation we can find the csa of working section:

$$A_2 = \frac{A_1V_1}{V_2} = \frac{0.25\ m^2 \cdot 30\frac{m}{s}}{84\frac{m}{s}} = 0.089\ m^2 \approx 0.09\ m^2$$

In physics and engineering, **mass flow rate** is the mass of a substance which passes through a given surface per unit of time.

Mass flow rate can be calculated by:

$$M = \rho \cdot V \cdot A$$

where

$$mass\ density\ of\ the\ air: \rho = 1.225 \frac{kg}{m^3}$$

$$velocity\ field\ of\ the\ mass: V = 30 \frac{m}{s}$$

$$cross - sectional\ area: A = 0.25\ m^2$$

Thus,

$$M = 1.225 \frac{kg}{m^3} \cdot 30 \frac{m}{s} \cdot 0.25\ m^2 = 9.1875 \frac{kg}{s}$$

Answer: $A_2 = 0.09\ m^2,\ \ M = 9.1875 \frac{kg}{s}$