Inside Wind Tunnel 2

The Bernoulli equation relates the pressure, elevation, and velocity of a fluid along a streamline. For an incompressible fluid, this equation is:

$$\frac{P_1}{\gamma} + \frac{{v_1}^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{{v_2}^2}{2g} + z_2$$

For the following experiment, z_1=z_2 and therefore cancels. Also, γ=ρg, which means g can be canceled from the remaining equation. Thus,

$$\frac{P_1}{\rho} + \frac{{v_1}^2}{2} = \frac{P_2}{\rho} + \frac{{v_2}^2}{2}$$

Now if we assume that the air starts outside of the duct at zero velocity (V_1=0) and that density remains fairly constant, we can calculate the velocity achieved inside the duct by the change in the pressure. Therefore,

$$\frac{P_1 - P_2}{\rho} = \frac{{v_2}^2}{2}$$

and in rearranging to get velocity,

$$v = \sqrt{\frac{2\Delta P}{\rho}}$$

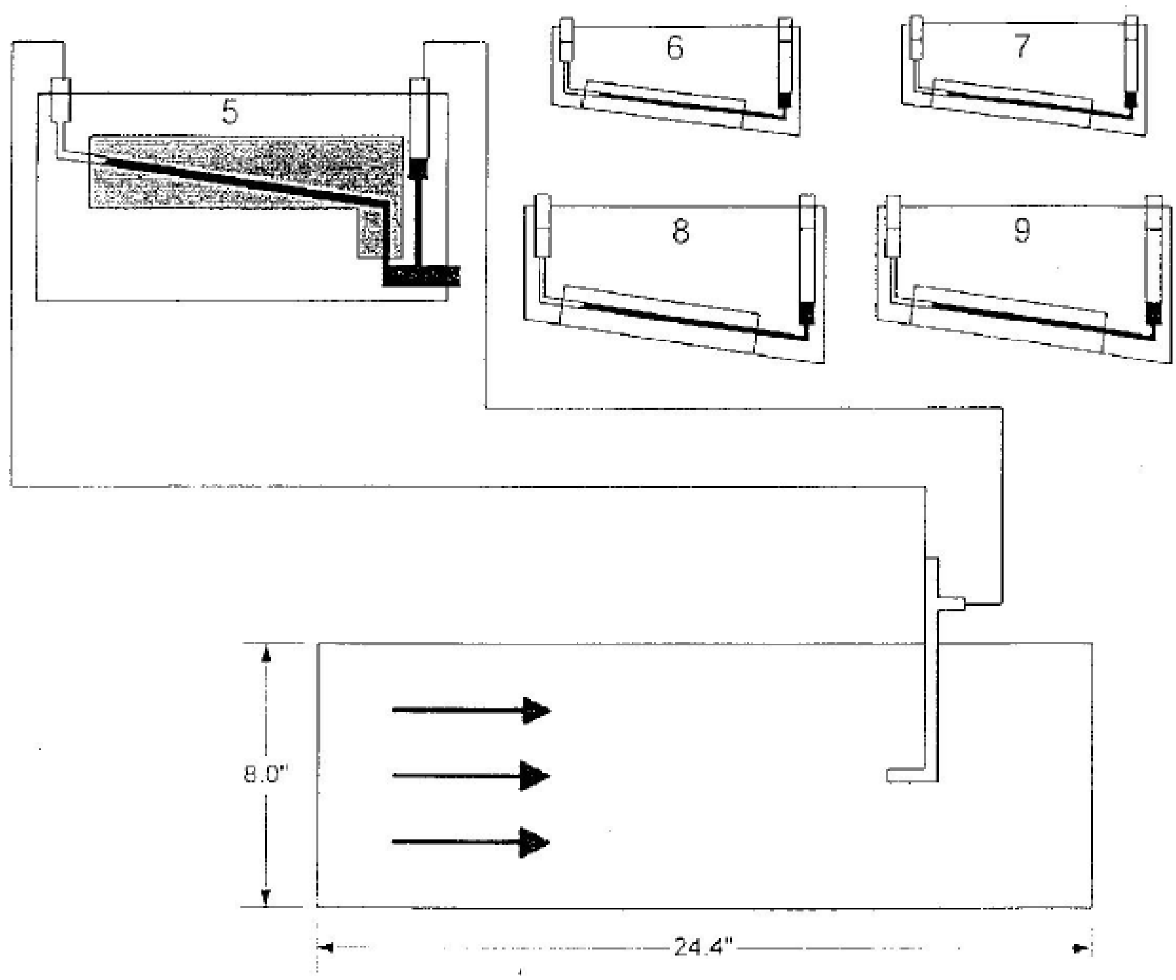
This allows us to find the velocity of the air inside the duct using the density of the air (ρ= 0.00233 $\frac{slug}{ft^3}$ at 70 ℉, 29.92 in_{Hg}). Also, since the manometers used are in W.C., we will substitute ΔP=ρgh (note that this ρ is for H_2O).

$$v = \sqrt{\frac{2\rho_{H2O}gh}{\rho}} = \sqrt{\frac{2 \cdot 1.93\frac{slug}{ft^3} \cdot 32.174\frac{ft}{s^2} \cdot h(in) \cdot \frac{1}{12}\frac{ft}{in}}{0.00233\frac{slug}{ft^3}}}$$

$v = 66.65\sqrt{h}\ \left(\frac{ft}{s}\right)$ or $v = 3998.8\sqrt{h}\ \left(\frac{ft}{min}\right)$ (where h is in inches)

Once we have the velocity, the volumetric flow rate can be calculated with

$$Q = v_{avg}A$$



Procedure:

1. Turn off the fan & power if necessary.
2. Install the straight duct as shown.
3. Zero manometer 5.
4. Connect the hoses to the appropriate manometer shown.
5. Insert the probe and center it.
6. Set the fan to each speed in the following table and record the pressures. When taking the readings, it is important to not shake or bump the table as well as to not walk near the inlet or exit of the wind tunnel.

Fan Speed Setting	Velocity Pressure (in_{H_2O})	Velocity (ft/s)	Volumetric Flow Rate (ft^3/s)
20			
40			
60			
80			

7. Next, leave the fan at the same speed (80) and move the probe up and down in 2 cm steps taking readings at each of these points.

Distance from Centerline (cm)	Velocity Pressure (in_{H_2O})	Velocity (ft/s)	Volumetric Flow Rate (ft^3/s)
-10.2	0	0	-
-10			
-8			
-6			
-4			
-2			
0			
2			
4			
6			
8			
10			
10.2	0	0	-

8. Calculate the velocity and volumetric flow rate for each measurement.
9. Graphically represent how distance from the centerline and fan speed effect velocity.
10. Answer the following questions in your conclusions/discussion section.

<u>Questions:</u>

1. Based on Bernoulli's equation, if the air velocity is tripled, by what factor would the pressure (ΔP) change? Compare this to the data in the first table.
2. What are the peak and average air velocities (in ft/s) based on the data in the second table?
3. Assuming that the duct is 8" deep, how much air (in ft^3/min [cfm]) is flowing through the section measured? How much air is flowing in the intake grill?