COE-C2003 Basic course on fluid mechanics, S2021

Round 2: The Bernoulli equation (return at the latest by Thu 30.9. at 13:00 o'clock)

Each problem (1-4) will be assessed on a scale of 0-3. Remember to explain the different stages in the solution. More detailed information can be found from MyCourses.

1. Briefly explain the following concepts. You may also add a figure (no copies from the book or from the lecture notes) to clarify the concept.
    a. Streamline, what does it mean ?
    b. Streakline ?
    c. Pathline ?

Answer:

a) A streamline is everywhere tangent to the velocity field. (a mathematical expressions to descrive the flow field. No direct correspondence to measurements).
b) A streakline is a line made by all the particles in the flow that have been previously released from the same location. Such a line can be produced by continuously injecting marked fluid (smoke in air or dye in liquid) at a given location.
c) Pathline is a line traced out by a given particle as it flows from one point to the another.

2. Air is drawn into a wind tunnel used for testing automobiles as shown in Fig. 1. (a) Determine the manometer reading, *h*, when the velocity in the test section is 100 km/h. Note that there is a 2.5cm column of oil (SG=0.90) on the water in the manometer. (b) Determine the difference between the stagnation pressure on the front of the automobile and the pressure in the test section. Air density is $\rho_{Air} = 1.2\ kg/m^3$.

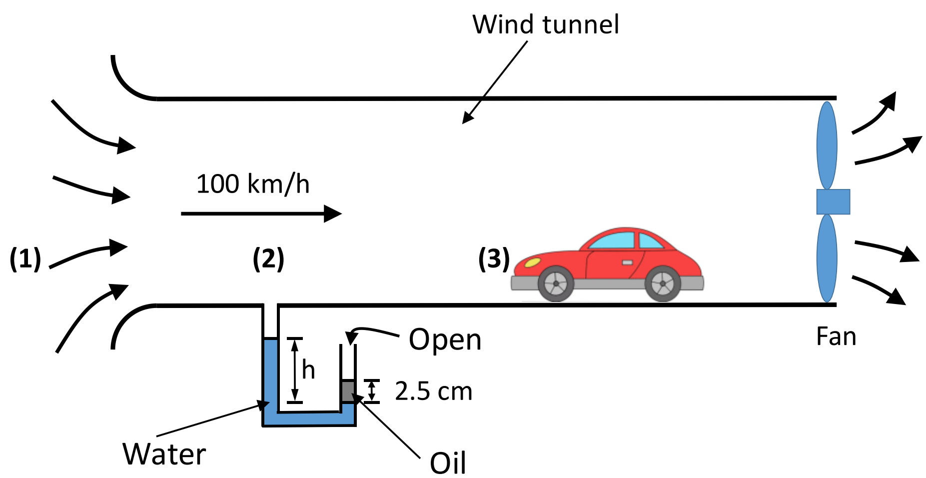

Figure 1. Problem 2

Answer:

(a) $p_1 + \frac{1}{2}\rho V_1^2 + \rho g z_1 = p_2 + \frac{1}{2}\rho V_2^2 + \rho g z_2$

Now $z_1 = z_2, p_1 = 0, and\ V_1 \sim 0$

Thus, with $V_2 = 100\frac{kg}{h} = 27.77\ m/s$

$$p_2 = -\frac{1}{2}\rho V_2^2 = -\frac{1}{2} \cdot 1.2\frac{kg}{m^3} \cdot \left(27.77\frac{m}{s}\right)^2 = -462.70\ Pa$$

However, $p_2 + \rho_{water} \cdot g \cdot h - \rho_{Oil} \cdot g \cdot 0.025m = 0$

We get

$$-462.7 + \frac{1000kg}{m3} * 9.81\frac{m}{s2} * h - 900\frac{kg}{m3} * \frac{9.81m}{s2} * 0.025m = 0$$

Or h=0.06966 m, h ~ 7 cm.

(b) $p_2 + \frac{1}{2}\rho V_2^2 + \rho g z_2 = p_3 + \frac{1}{2}\rho V_3^2 + \rho g z_3$

Now $z_2 = z_3$ and $V_3 = 0$

Thus

$$p_2 + \frac{1}{2}\rho V_2^2 = p_3$$

$$p_3 - p_2 = \frac{1}{2}\rho V_2^2 = \frac{1}{2}1.2\frac{kg}{m3} * \left(27.77\frac{m}{s}\right)^2 = 462.7\ Pa$$

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3 A fire hose nozzle has a diameter of 3 cm. According to some fire codes, the nozzle must be capable of delivering at least 750 liters/min. If the nozzle is attached to a 7.5 cm diameter hose, what pressure must be maintained just upstream of the nozzle to deliver this flowrate ?

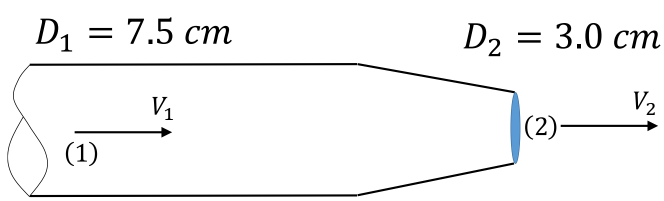


Figure 2. Problem 3

Answer:

Bernoulli between (1) and (2)

$$p_1 + \frac{1}{2}\rho V_1^2 + \rho g z_1 = p_2 + \frac{1}{2}\rho V_2^2 + \rho g z_2$$

Now $p_2 = 0$ for a free jet. Also $z_1 = z_2$.

Volume flow rate $Q = 750\ liters/\min = 12.5\frac{liters}{s} = 0.0125\ m^3/s$

Thus

$$p_1 = \frac{1}{2}\rho(V_2^2 - V_1^2)$$

Where $V_1 = \frac{Q}{A_1} = \frac{0.0125}{\pi\left(\frac{0.075}{2}\right)^2} = 2.829\ m/s$

and $V_2 = \frac{Q}{A_2} = \frac{0.0125}{\pi\left(\frac{0.030}{2}\right)^2} = 17.683\ m/s$

We obtain

$$p_1 = \frac{1}{2}\rho(V_2^2 - V_1^2) = 0.5 * 1000\frac{kg}{m3}(17.683^2 - 2.829^2)$$
$$= 152'342.6\ Pa \sim 152\ kPa\ (\text{or} \sim 1.52\ bar)$$

1. Plot some curves with Matlab (plot-command). Plot the equation $y^2 = C\ kx$ with Matlab using values for k as *k*=0, *k*=1 ja *k*=2. *C* is a constant and it is defined according to your student number's last digit (if it is zero, then C=10). Define x between 0-20, in 0.25 steps. Plot only positive y-values. Plot all the three curves to the same figure (hold on -command). In the answer, there should be both the code and the figure.

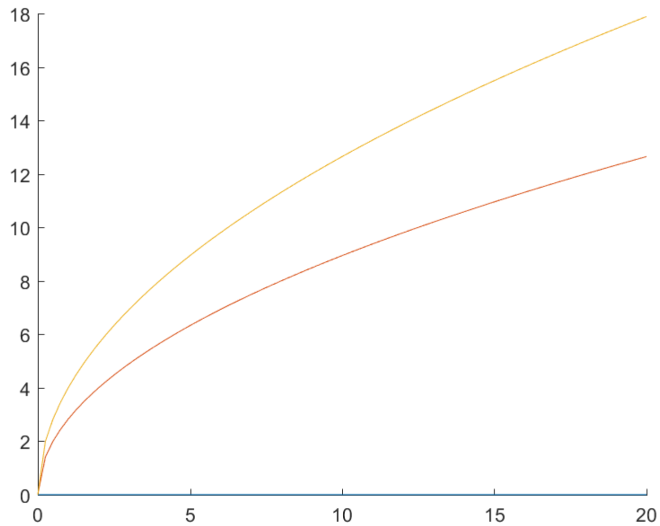
   It is recommended to again start by creating a new script (top menu, left, New -> script). You can save the figure e.g. in png as follows "saveas(fig1,'Round2','png'); " (Define first fig1=figure(1)). Saving in pdf can be done by just using 'pdf' instead of 'png'.

Answer:

```
% y2=Ckx, where C=8 ja k=0, 1 ja 2.
x=[0:0.25:20];
y1=0.*x;
y2=8^0.5*x.^0.5
y3=16^0.5*x.^0.5;

fig1=figure(1)
hold on
plot(x,y1)
hold on
plot(x,y2)
plot(x,y3)

saveas(fig1,'Round2','png');
```



The plotted curves (k=0, k=1, and k=2).