KATHMANDU UNIVERSITY

SCHOOL OF SCIENCE

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

MINI-PROJECT PROPOSAL

MINI-PROJECT ON BERNOULLI'S THEOREM

BY:

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GROUP : COMPUTER SCIENCE 1ST SEM(2021)

ROLL NO : 02

SUBMISSION DATE : 07/28/2021

Table of Contents

Table of Contents

SUMMARY

This paper is the second part and the complete paper of the mini-project assigned by our Elements of Engineering course ENGG111, course instructor Saroj Gautam sir as Individual project. This paper is a well-documented full-fledged project demonstration by me, Prajwal Adhikari, a student of class 2020 Computer science. This paper introduces a detailed discussion on Bernoulli's principle, the fundamental theorem in fluid mechanics and its implementation in solving numerical using C programming language . Going through this paper you will find a detailed discussion on Bernoulli's Principle, its derivation. The theorem then will be applied over a reference problem statement and checked over 3 more cases. As the main goal of the mini project is to apply Bernoulli's Principle using C programming language, a short but up to the point program description is introduced giving my approach to implement the principle using C programming language. Moreover, program walkthrough is also presented so as to be clear about our main interest with the project. Going deep down a detailed step by step algorithmic approach to the problem is presented which is then will be backed up by a flowchart giving a visual representation of my approach. At last, I want to conclude this summary by saying thank you to our course instructor for introducing a very new and effective approach for our evaluation.

INTRODUCTION

Bernoulli’s equation formula is a relation between pressure, kinetic energy, and gravitational potential energy of a fluid system. The principle is named after Daniel Bernoulli who published it in his book Hydrodynamica in 1738. The principle is applicable for isentropic flows: when the effects of irreversible processes (like turbulence) and non-adiabatic processes (e.g. heat radiation) are small and can be neglected. Bernoulli's principle can be applied to various types of fluid flow, resulting in various forms of Bernoulli's equation. The simple form of Bernoulli's equation is valid for incompressible flows (e.g. most liquid flows and gases moving at low Mach number). More advanced forms may be applied to compressible flows at higher Mach numbers (see the derivations of the Bernoulli equation).

OBJECTIVES:

1. To discuss the fundamentals of Bernoulli’s theorem.
2. To solve different cases on the fundamental problem statement using Bernoulli’s theorem.

BERNOULLI’S PRINCIPLE

The Swiss physicist Daniel Bernoulli first derived the relationship between fluid speed, pressure, and elevation in 1738. Although Bernoulli deduced the law, it was Leonhard Euler who derived Bernoulli’s equation in its usual form in the year 1752.

STATEMENT

Bernoulli's principle states," The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant."

The formula for Bernoulli's principle is given as:

$$p + \frac{1}{2}\rho v^2 + \rho gh = \text{constant} \text{ ---------- } (1)$$

Where,

- p is the pressure exerted by the fluid
- v is the velocity of the fluid
- ρ is the density of the fluid
- h is the height of the container

Bernoulli's equation gives great insight into the balance between pressure, velocity and elevation. This expression specifies that, in laminar flow, the sum of the pressure (P), kinetic energy per unit volume ($\frac{1}{2}\rho v^2$) and gravitational potential energy per unit volume (ρgh) has the same value at all points along a streamline.

BERNOULLI'S EQUATION DERIVATION

Bernoulli's principle can be derived from the principle of conservation of energy. Consider a pipe with varying diameter and height through which an incompressible fluid is flowing. The relationship between the areas of cross-sections A, the flow speed v, height from the ground y, and pressure p at two different points 1 and 2 is given in the figure below.

Followings are the assumption made for the deduction of Bernoulli's principle:

- The energy of the fluid is conserved as there are no viscous forces in the fluid.
- The density of the incompressible fluid remains constant at both points.

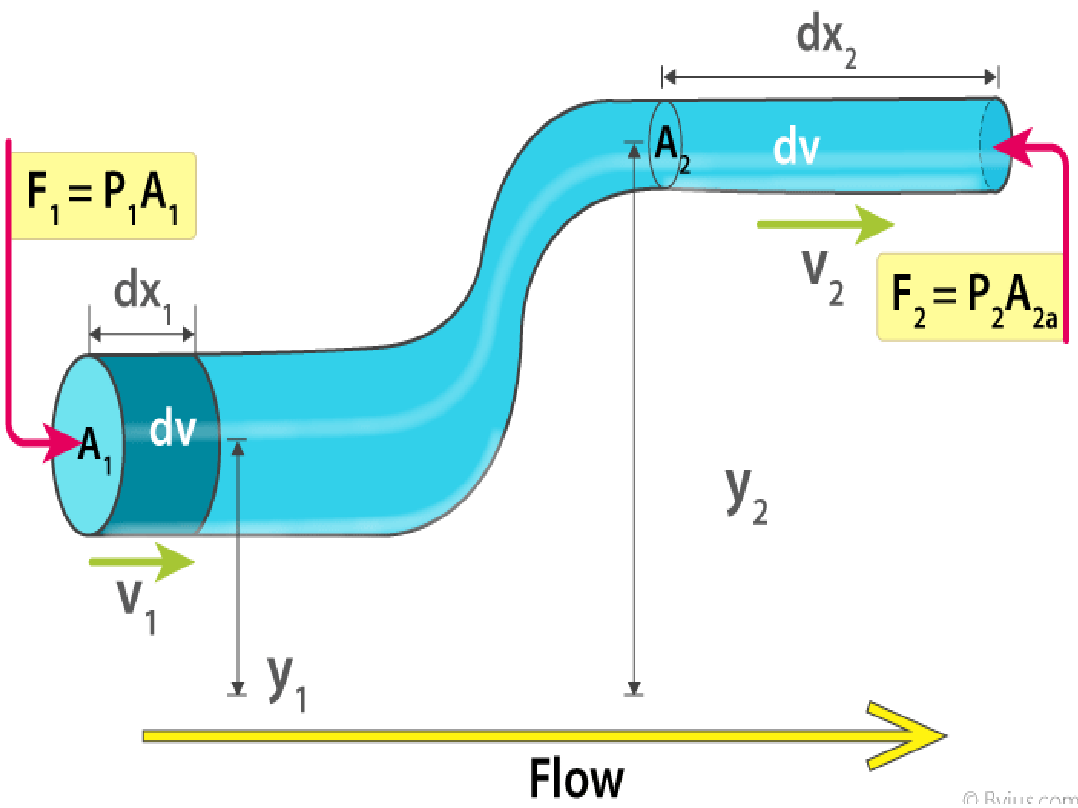


Fig 1.1: Bernoulli's Theorem

Therefore, the work done on the fluid is given as:

$dW = F_1dx_1 – F_2dx_2$

$dW = p_1A_1dx_1 – p_2A_2dx_2$

$dW = p_1dV – p_2dV = (p_1 – p_2)dV$

We know that the work done on the fluid was due to conservation of gravitational force and change in kinetic energy. The change in kinetic energy of the fluid is given as:

$$dK = \frac{1}{2}m_2 v_2^2 - \frac{1}{2}m_1 v_1^2$$

$$= \frac{1}{2}\rho dV(v_2^2 - v_1^2)$$

The change in potential energy is given as:

$$dU = mgy_2 - mgy_1 = \rho dVg(y_2 - y_1)$$

Therefore, the energy equation is given as:

$$dW = dK + dU$$

$$(p_1 - p_2)dV = \frac{1}{2}\rho dV(v_2^2 - v_1^2) + \rho dVg(y_2 - y_1)$$

$$(p_1 - p_2) = \frac{1}{2}\rho(v_2^2 - v_1^2) + \rho g(y_2 - y_1)$$

Rearranging the above equation, we get

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 \text{ ---(2)}$$

This is Bernoulli's equation.

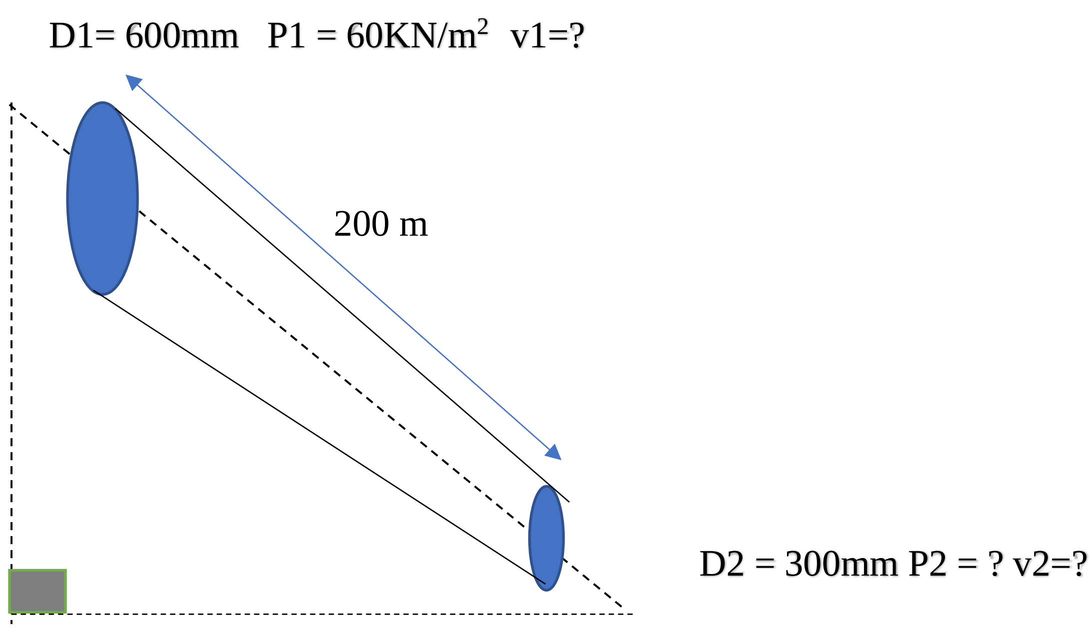
PROBLEM DEFINITON

A pipe 200m long slopes down at 1 in 100 and tapers from 600 mm diameter at the higher end to 300 mm diameter at the lower end, and carries 100 liters/sec of oil (sp. Gravity 0.8). If the pressure gauge at the higher end reads 60 KN/m^2

Determine :

1. Velocities at both ends
2. Pressure at the lower end

CASE 1:



or, Slope = $\frac{\text{Rise}}{\text{Run}}$

$= \frac{1}{100}$

or, $\tan\Theta = \frac{1}{100}$

or, $\Theta = \text{Tan}^{-1}(\frac{1}{100}) = 0.57294$

For height,

$\sin\Theta = \frac{\text{Height(h)}}{\text{lenght(l)}}$

or, height(h) = length(l) * sin Θ

or, height(h) = 200 * sin(0.57294) = 1.99999 $\approxeq$ 2 m

specific gravity of oil = 0.8

or, $\frac{\text{Density of oil}}{\text{Density of water}} = 0.8$

or, density of oil = 0.8 * density of water

or, density of oil = 0.8 * 1000

or, density of oil = = 800 Kg/m^3.

Flow of water in pipe = 100 liters/sec

i.e.

Flow of water in pipe = $\frac{100}{1000} = 0.1\ m^3/sec$

We know that,

Flow rate (Q) = Area(A) * Velocity(V)

For velocity v1,

$Q_1 = A_1 * V_1$

or, $0.1 = \frac{\pi}{4} * (d_1)^2 * v_1$

or, $v_1 = \frac{0.1*4}{\pi*(0.6)*(0.6)} = 0.35368$ m/sec

Using Bernoulli's Principle,

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * v_2^2 + \rho g * 0$

or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * v_2^2$ ---------(3)

Again,

Applying Equation of continuity,

$A_1 V_1 = A_2 V_2$

Or, $\frac{\pi}{4} * (d1)^2 * v_1 = \frac{\pi}{4} * (d2)^2 * v_2$

Or, $(0.6)^2 * 0.35368 = (0.3)^2 * v_2$

Or, $v_2 = 1.41472$ m/sec

Finally,

Or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * (1.41472)^2$

Or, $75730.035 = P_2 + 800.573$

Or, $P_2 = 75730.035 - 800.573$

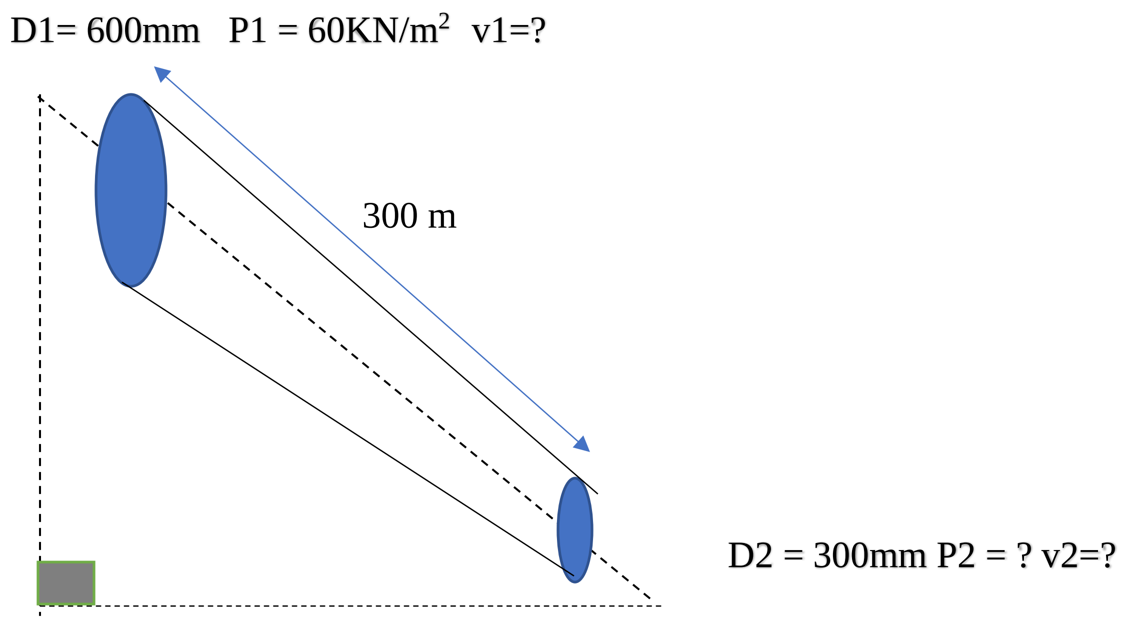
Or, $P_2 = 74929.462 N/m^2$

i.e.

$P_2 = 74.92 KN/m^2$

Therefore the pressure at the lower end of the pipe is 74.92 KN/m^2

CASE 2 :



For second case we take all the initial condition same except the length of the pipe. Here we take the length of pipe as 300m. Lets find out the possible outcomes for this condition.

Increasing length of pipe by 100 meters,

i.e. Length(l) = 300 m

or, Slope = $\frac{\text{Rise}}{\text{Run}}$

$= \frac{1}{100}$

or, $\tan\Theta = \frac{1}{100}$

or, $\Theta = Tan^{-1}(\frac{1}{100}) = 0.57294$

For height,

$\sin\Theta = \frac{\text{Height(h)}}{\text{lenght(l)}}$

or, height(h) = length(l) * sin Θ

or, height(h) = 300 * sin(0.57294) = 2.99982 $\approxeq$ 3 m

specific gravity of oil = 0.8

or, $\frac{\text{Density of oil}}{\text{Density of water}} = 0.8$

or, density of oil = 0.8 * density of water

or, density of oil = 0.8 * 1000

or, density of oil = = 800 Kg/m^3.

Flow of water in pipe = 100 liters/sec

i.e.

Flow of water in pipe = $\frac{100}{1000}$ = 0.1 m^3/sec

We know that,

Flow rate (Q) = Area(A) * Velocity(V)

For velocity v1,

$Q_1 = A_1 * V_1$

or, $0.1 = \frac{\pi}{4} * (d_1)^2 * v_1$

or, $v_1 = \frac{0.1*4}{\pi*(0.6)*(0.6)} = 0.35368$ m/sec

Using Bernoulli's Principle,

$$P_1 + \frac{1}{2}\rho\, v_1^2 + \rho g\, h_1 = P_2 + \frac{1}{2}\rho\, v_2^2 + \rho g\, h_2$$

or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * v_2^2 + \rho g * 0$

or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * v_2^2$ ---------(3)

Again,

Applying Equation of continuity,

$A_1 V_1 = A_2 V_2$

Or, $\frac{\pi}{4} * (d_1)^2 * v_1 = \frac{\pi}{4} * (d_1)^2 * v_2$

Or, $(0.6)^2 * 0.35368 = (0.3)^2 * v_2$

Or, $v_2 = 1.41472$ m/sec

Finally,

Or, $6 * 10^4 + \frac{1}{2} * 800 * (0.35368)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * (1.41472)^2$

Or, $83570.035 = P_2 + 800.573$

Or, $P_2 = 83570.035 – 800.573$

Or, $P_2 = 82769.462 N/m^2$

i.e.

$P_2 = 82.76 KN/m^2$

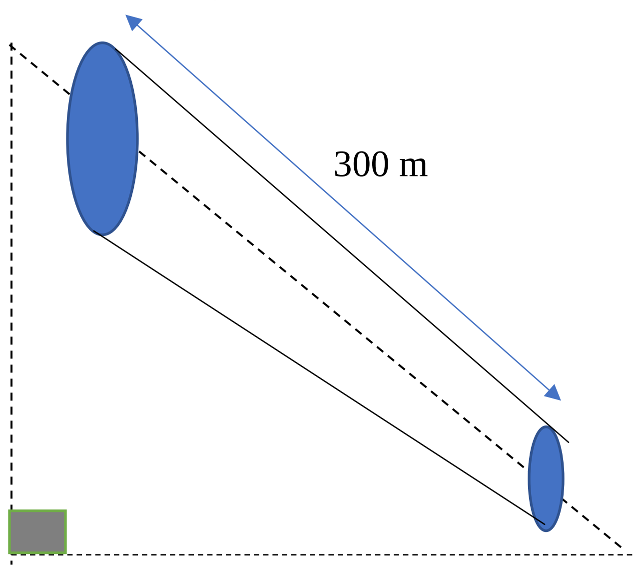
Therefore the pressure at the lower end of the pipe is 82.76KN/m^2

CASE 3 :

Type equation here.

For third case we take all the initial condition same except the flow of oil in the pipe when then length of pipe is 300m. Here we take the length of pipe as 300m and flow of oil as 300 liters/sec. Lets find out the possible outcomes for this condition.

D1= 600mm Q = 300 liters/sec P1 = 60KN/m^2 v1=?



D2 = 300mm P2 = ? v2=?

or, Slope = $\frac{\text{Rise}}{\text{Run}}$

$= \frac{1}{100}$

or, TanΘ = $\frac{1}{100}$

or, Θ = $\tan^{-1}(\frac{1}{100})$ = 0.57294

For height,

$\sin \Theta = \dfrac{\text{Height(h)}}{\text{lenght(l)}}$

or, height(h) = length(l) * sin Θ

or, height(h) = 300 * sin(0.57294) = 2.99985 $\approxeq$ 3 m

specific gravity of oil = 0.8

or, $\dfrac{\text{Density of oil}}{\text{Density of water}} = 0.8$

or, density of oil = 0.8 * density of water

or, density of oil = 0.8 * 1000

or, density of oil = = 800 Kg/m^3.

Flow of water in pipe = 300 liters/sec

i.e.

Flow of water in pipe = $\dfrac{300}{1000}$ = 0.3 m^3/sec

We know that,

Flow rate (Q) = Area(A) * Velocity(V)

For velocity v1,

$Q_1 = A_1 * V_1$

or, $0.3 = \frac{\pi}{4} * (d_1)^2 * v_1$

or, $v_1 = \frac{0.3*4}{\pi*(0.6)*(0.6)}$ = 1.06103 m/sec

Using Bernoulli's Principle,

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

or, $6 * 10^4 + \frac{1}{2} * 800 * (1.06103)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * v_2^2 + \rho g * 0$

or, $6 * 10^4 + \frac{1}{2} * 800 * (1.06103)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * v_2^2$ --------- (3)

Again,

Applying Equation of continuity,

$A_1 V_1 = A_2 V_2$

Or, $\frac{\pi}{4} * (d_1)^2 * v_1 = \frac{\pi}{4} * (d_1)^2 * v_2$

Or, $(0.6)^2 * 1.06103 = (0.3)^2 * v_2$

Or, $v_2 = 4.24412$ m/sec

Finally,

Or, $6 * 10^4 + \frac{1}{2} * 800 * (1.06103)^2 + 800 * 9.8 * 3 = P_2 + \frac{1}{2} * 800 * (4.24412)^2$

Or, $83970.313 = P_2 + 7205.021$

Or, $P_2 = 83970.3163 - 7205.021$

Or, $P_2 = 76765.292 N/m^2$

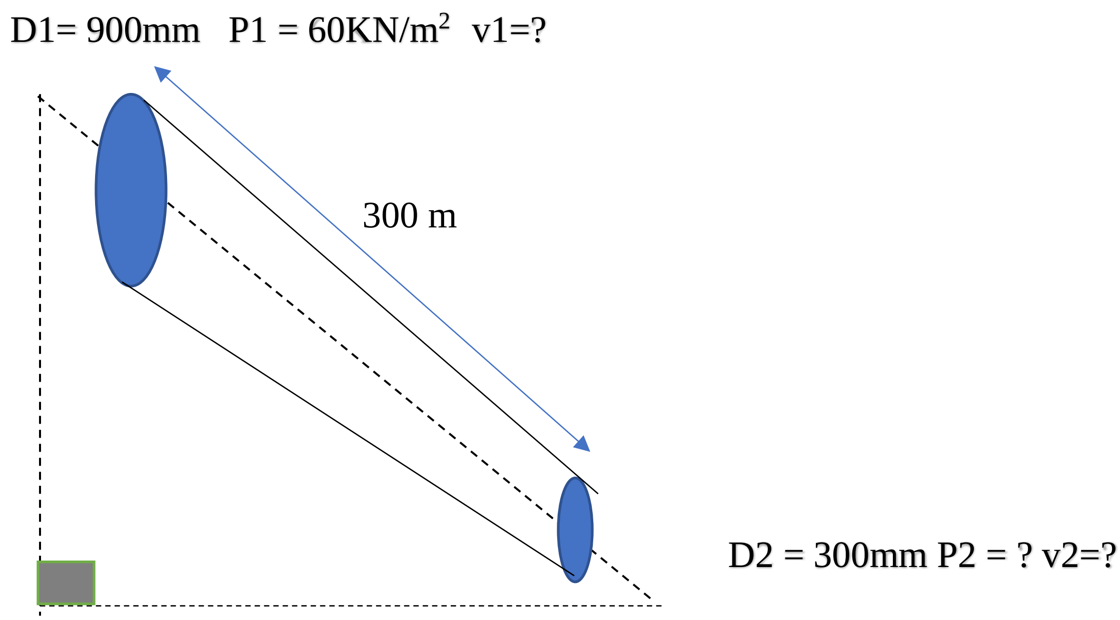
i.e.

$P_2 = 76.765 KN/m^2$

Therefore the pressure at the lower end of the pipe is 76.765 KN/m^2

CASE 4 :

For third case we take all the initial condition same except the upper diameter of pipe. Lets take $d_1 = 900$ mm



or, Slope = $\frac{\text{Rise}}{\text{Run}}$

$= \frac{1}{100}$

or, Tanϴ = $\frac{1}{100}$

or, ϴ = $\tan^{-1}(\frac{1}{100})$ = 0.57294

For height,

$\sin \Theta = \frac{\text{Height(h)}}{\text{lenght(l)}}$

or, height(h) = length(l) * sin Θ

or, height(h) = 200 * sin(0.57294) = 1.99999 $\approxeq$ 2 m

specific gravity of oil = 0.8

or, $\frac{\text{Density of oil}}{\text{Density of water}} = 0.8$

or, density of oil = 0.8 * density of water

or, density of oil = 0.8 * 1000

or, density of oil = = 800 Kg/m^3.

Flow of water in pipe = 100 liters/sec

i.e.

Flow of water in pipe = $\frac{100}{1000}$ = 0.1 m^3/sec

We know that,

Flow rate (Q) = Area(A) * Velocity(V)

For velocity v1,

$Q_1 = A_1 * V_1$

or, $0.1 = \frac{\pi}{4} * (d_1)^2 * v_1$

or, $v_1 = \frac{0.1*4}{\pi*(0.9)*(0.9)} = 0.15719$ m/sec

Using Bernoulli's Principle,

$$P_1 + \frac{1}{2}\rho\, v_1^2 + \rho g\, h_1 = P_2 + \frac{1}{2}\rho\, v_2^2 + \rho g\, h_2$$

$$\text{or, } 6 * 10^4 + \frac{1}{2} * 800 * (0.15719)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * v_2^2 + \rho g * 0$$

$$\text{or, } 6 * 10^4 + \frac{1}{2} * 800 * (0.15719)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * v_2^2 \text{ ---------(3)}$$

Again,

Applying Equation of continuity,

$A_1 V_1 = A_2 V_2$

Or, $\frac{\pi}{4} * (d1)^2 * v_1 = \frac{\pi}{4} * (d2)^2 * v_2$

Or, $(0.9)^2 * 0.15719 = (0.3)^2 * v_2$

Or, $v_2 = 1.41471$ m/sec

Finally,

$$\text{Or,} 6 * 10^4 + \frac{1}{2} * 800 * (0.15719)^2 + 800 * 9.8 * 2 = P_2 + \frac{1}{2} * 800 * (1.41471)^2$$

Or, $75689.883 = P_2 + 800.561$

Or, $P_2 = 75689.883 - 800.561$

Or, $P_2 = 74889.322 N/m^2$

i.e.

$P_2 = 74.889\ KN/m^2$

Therefore the pressure at the lower end of the pipe is $74.889\ KN/m^2$

PROGRAM DESCRIPTION

For the implementation of Bernoulli's principle in problem statement, C programming language is used. The program is a console- based program backed by file handling in C where a user will input the necessary conditions via console in order to get the desired output in a CSV file. Inputs is given through keyboard following the guidance given by the program itself. Different cases can be generated by user him/her self, giving valid user inputs. Outputs will be stored in a outputs.csv file. User may open this file using Excel for better experience. I used my existing knowledge on C language and more through research and practice. The whole program is written as clean as possible by using functions, structural blocks, pointers etc. Writing clean and effective code which uses minimum resources is the main motive of this project.

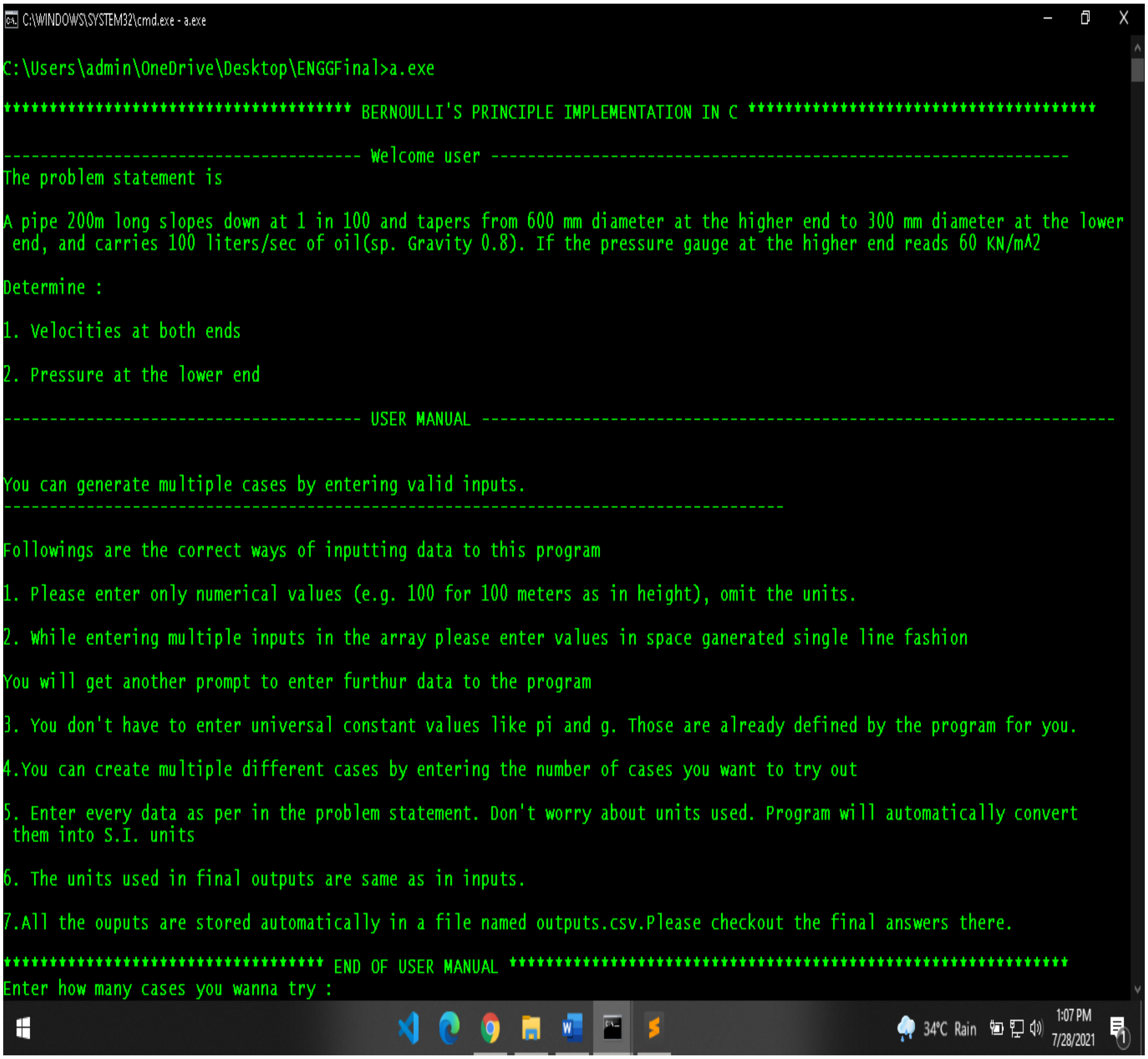
Using the function driven approach each block of code is wrapped inside a function to reduce redundancy. At first the user is greeted by a welcome message where they will have to press return to proceed. A user manual is prompted telling user what the program does and help them to enter inputs in valid way. After getting the input from the user the program executes giving the required values. Note: Different outputs are the results of variation in user inputs

I had this idea of visualizing the outputs using matplotlib using python. I did a bit of research in using python libraries like pandas and numpy for data visualization. Then I used the knowledge to plot line graphs for data visualization.

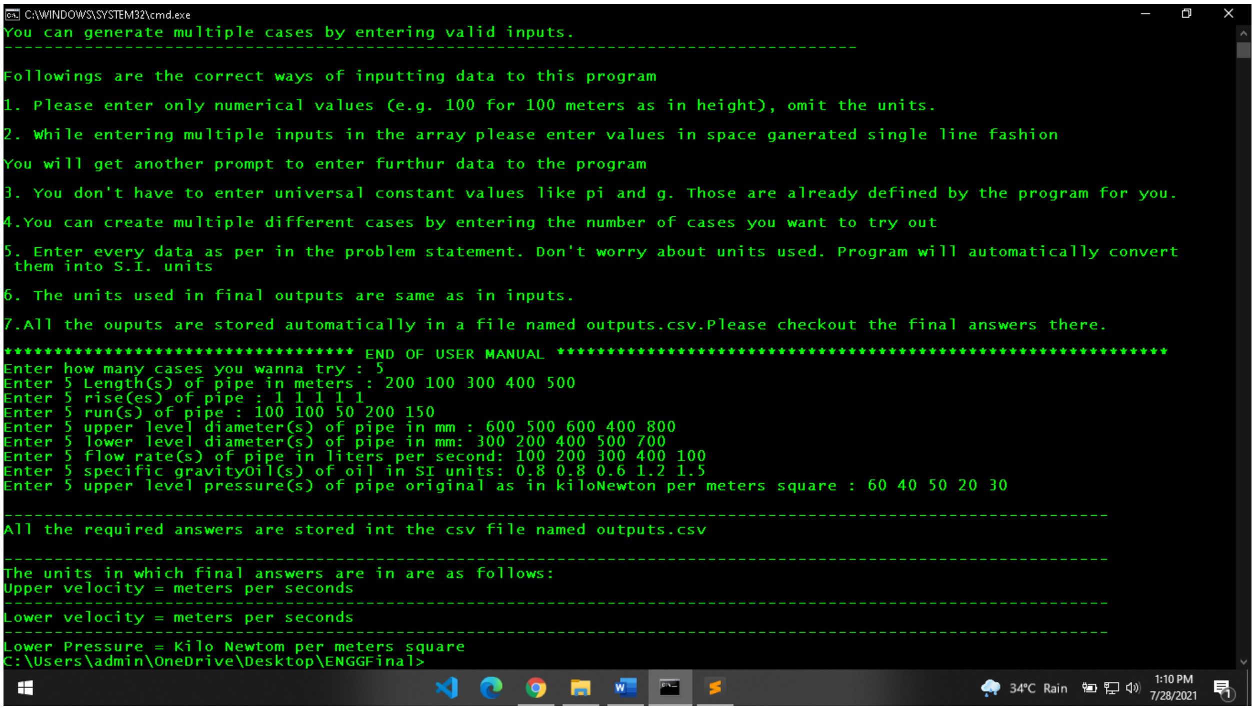
PROGRAM WALKTHROUGH

Here is what exactly this program does. At first a user is greeted by a greeting function. Then he/she is prompted by a user manual to use the program accurately.

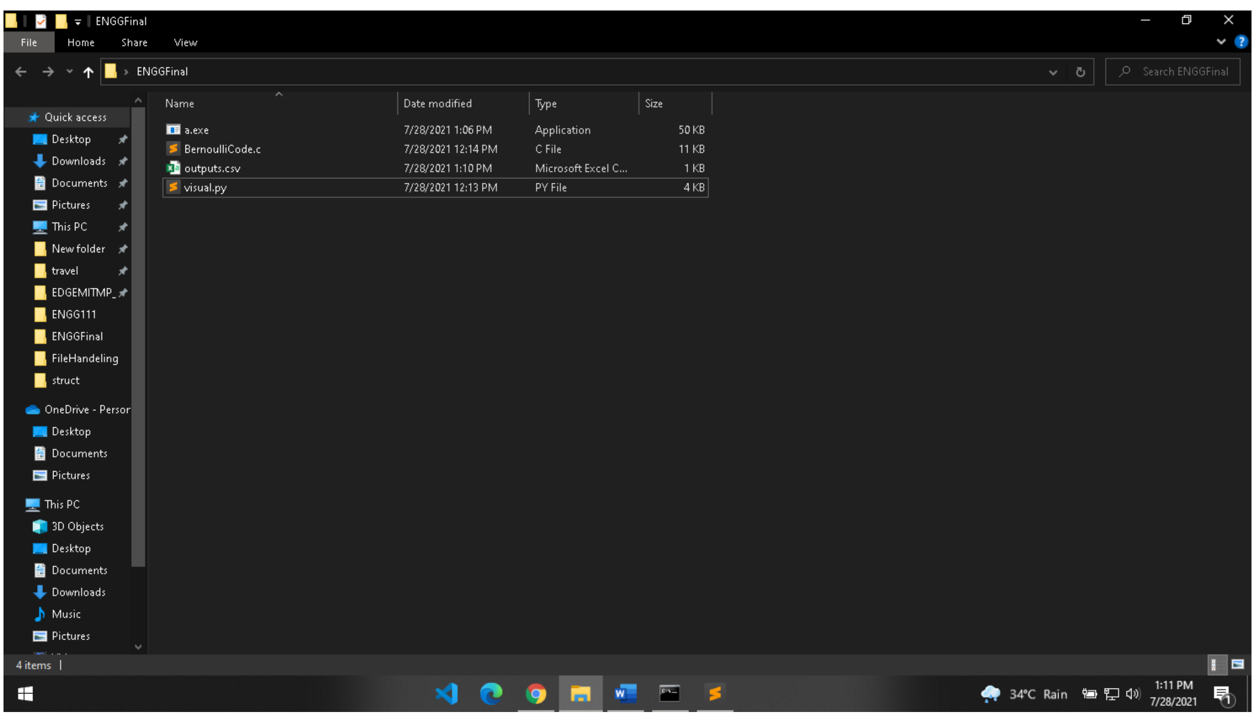
User is now asked to enter the number of different cases they want to try out.



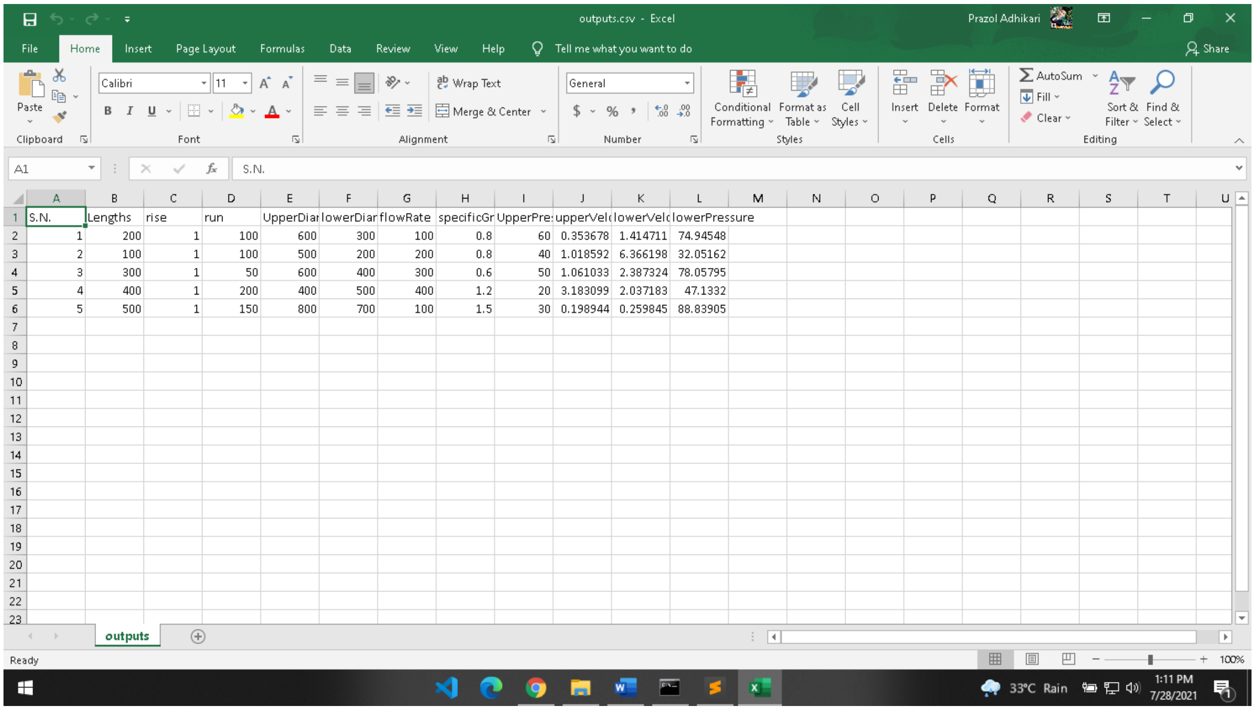
```
C:\WINDOWS\SYSTEM32\cmd.exe - a.exe

C:\Users\admin\OneDrive\Desktop\ENGGFinal>a.exe

************************************* BERNOULLI'S PRINCIPLE IMPLEMENTATION IN C *************************************

--------------------------------------- Welcome user ---------------------------------------------------------------
The problem statement is

A pipe 200m long slopes down at 1 in 100 and tapers from 600 mm diameter at the higher end to 300 mm diameter at the lower
 end, and carries 100 liters/sec of oil(sp. Gravity 0.8). If the pressure gauge at the higher end reads 60 KN/m^2

Determine :

1. Velocities at both ends

2. Pressure at the lower end

--------------------------------------- USER MANUAL ---------------------------------------------------------------------


You can generate multiple cases by entering valid inputs.
------------------------------------------------------------------------------------

Followings are the correct ways of inputting data to this program

1. Please enter only numerical values (e.g. 100 for 100 meters as in height), omit the units.

2. While entering multiple inputs in the array please enter values in space ganerated single line fashion

You will get another prompt to enter furthur data to the program

3. You don't have to enter universal constant values like pi and g. Those are already defined by the program for you.

4.You can create multiple different cases by entering the number of cases you want to try out

5. Enter every data as per in the problem statement. Don't worry about units used. Program will automatically convert
 them into S.I. units

6. The units used in final outputs are same as in inputs.

7.All the ouputs are stored automatically in a file named outputs.csv.Please checkout the final answers there.

********************************** END OF USER MANUAL *************************************************************
Enter how many cases you wanna try :
```



Once the program gets this input it executes and asks user to enter all the different data into the program. Once all the inputting is done the program runs and spits out a output in the console saying look for the output in outputs.csv file as this project or I should say this program uses file handling in C.



Then the user has to open the outputs.csv file to get all the outputs for different cases they had created.

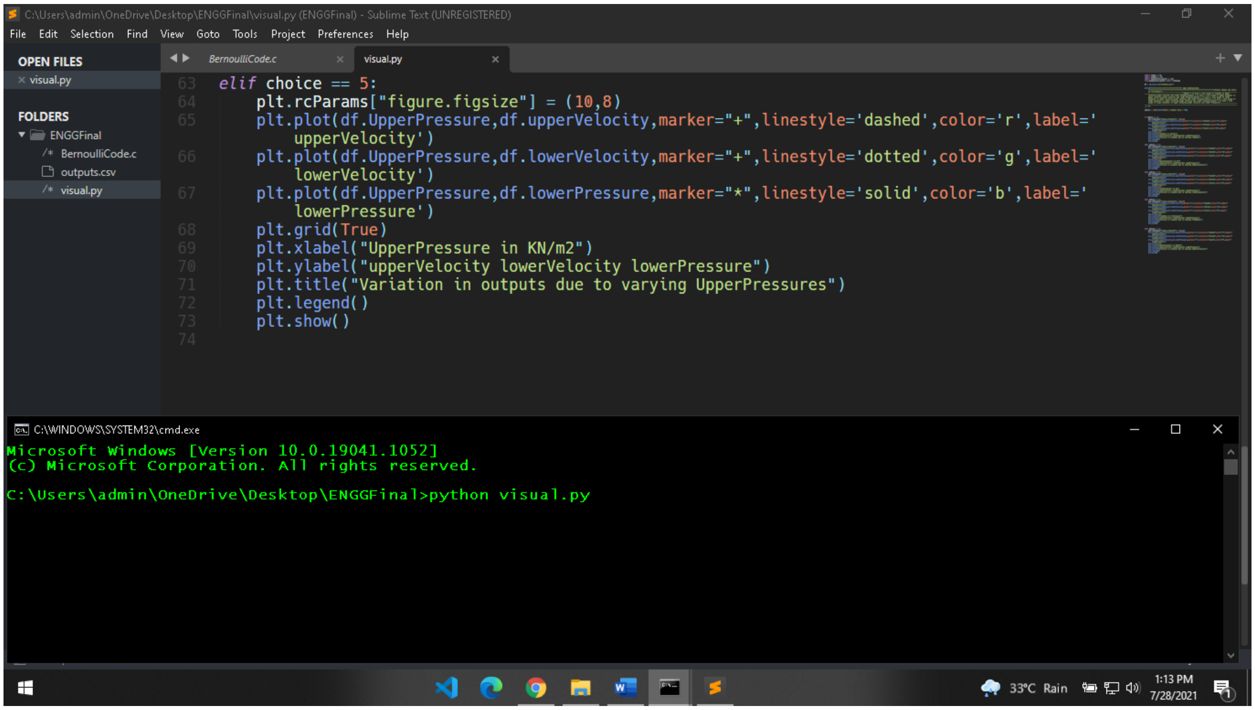


S.N.	Lengths	rise	run	UpperDiar	lowerDiar	flowRate	specificGr	UpperPre:	upperVel(	lowerVel(	lowerPressure
1	200	1	100	600	300	100	0.8	60	0.353678	1.414711	74.94548
2	100	1	100	500	200	200	0.8	40	1.018592	6.366198	32.05162
3	300	1	50	600	400	300	0.6	50	1.061033	2.387324	78.05795
4	400	1	200	400	500	400	1.2	20	3.183099	2.037183	47.1332
5	500	1	150	800	700	100	1.5	30	0.198944	0.259845	88.83905

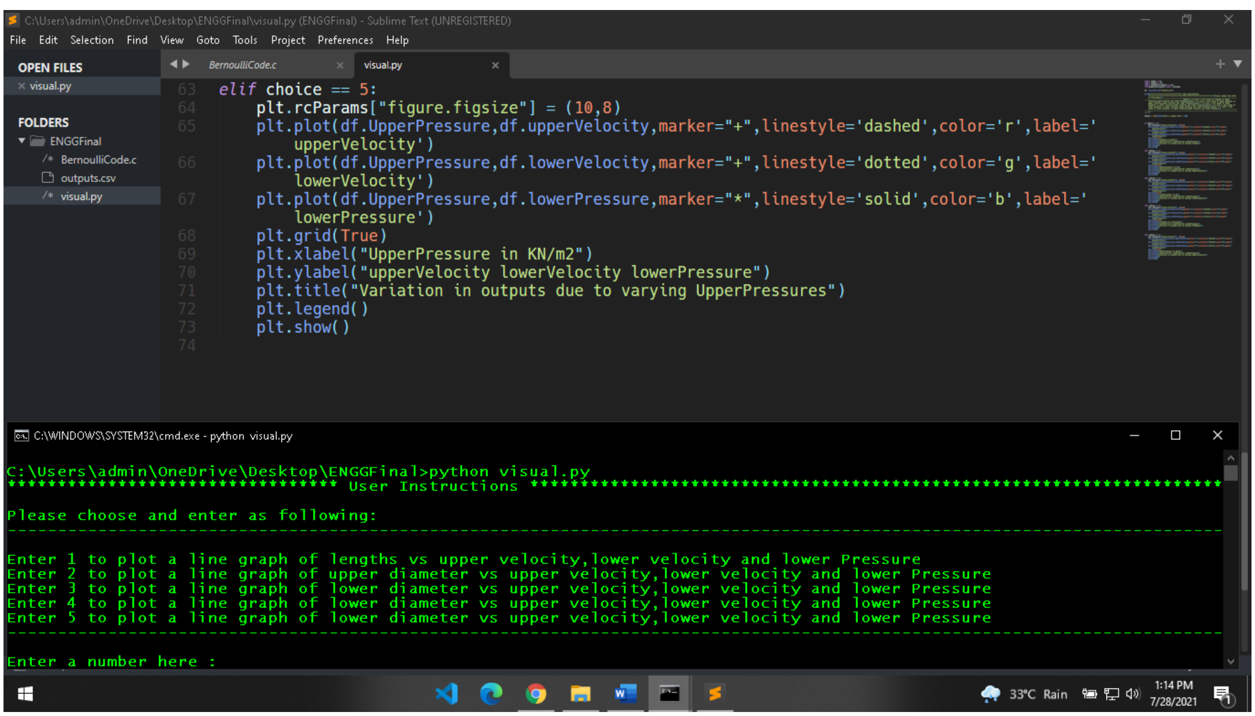
Now as the calculation and output part is done ,the next phase of the project is the data visualization. As C language really not that easy and useful for data visualization, Python our favourite buddy comes in handy. Here python libraries like PANDAS and MATPLOTLIB are used.

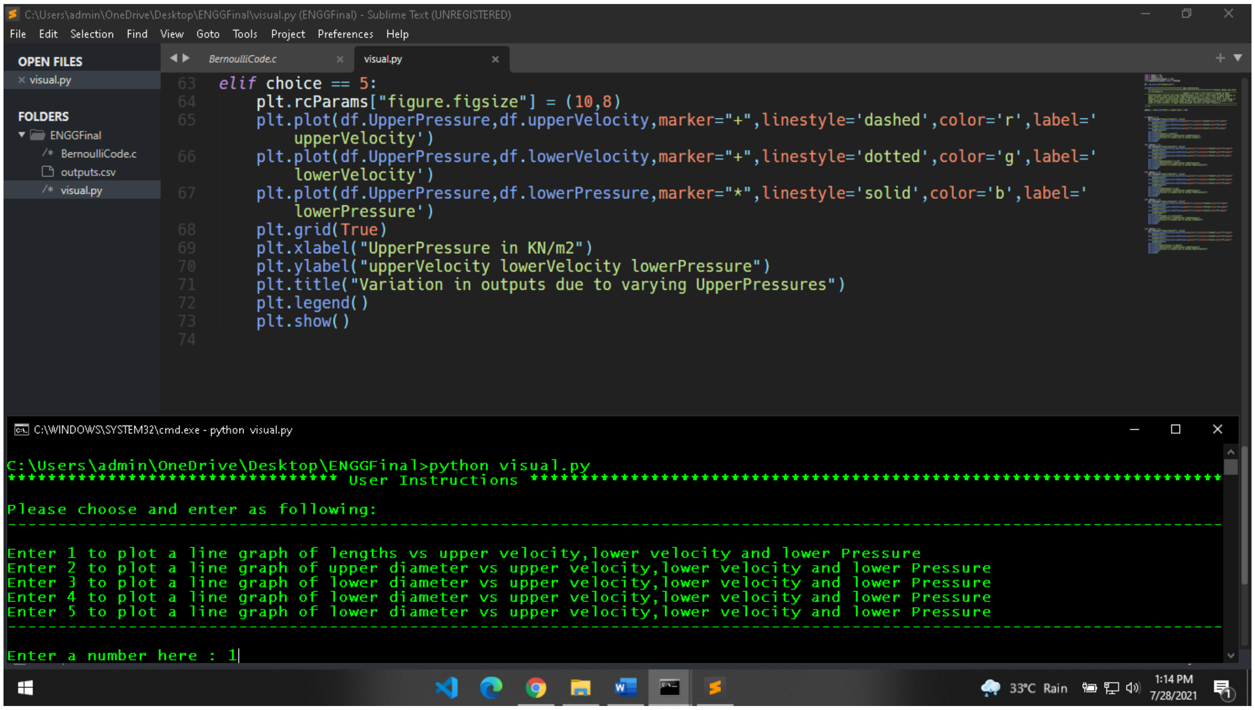
So any user using this program must have pandas and matplotlib installed in his/her device.

So, talking about the data visualization part, the user has to run the python script named visualization.py by writing python visualization.py in the terminal opened in the project directory.



Then user is welcomed and presented with different choices. User has to choose a option by enter a number 1,2,3,.. of his choice so as to visualize different line graphs.




C:\Users\admin\OneDrive\Desktop\ENGGFinal\visual.py (ENGGFinal) - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
OPEN FILES
visual.py
FOLDERS
ENGGFinal
BernoulliCode.c
outputs.csv
visual.py
elif choice == 5:
plt.rcParams["figure.figsize"] = (10,8)
plt.plot(df.UpperPressure,df.upperVelocity,marker="+",linestyle='dashed',color='r',label='upperVelocity')
plt.plot(df.UpperPressure,df.lowerVelocity,marker="+",linestyle='dotted',color='g',label='lowerVelocity')
plt.plot(df.UpperPressure,df.lowerPressure,marker="*",linestyle='solid',color='b',label='lowerPressure')
plt.grid(True)
plt.xlabel("UpperPressure in KN/m2")
plt.ylabel("upperVelocity lowerVelocity lowerPressure")
plt.title("Variation in outputs due to varying UpperPressures")
plt.legend()
plt.show()
C:\WINDOWS\SYSTEM32\cmd.exe - python visual.py
C:\Users\admin\OneDrive\Desktop\ENGGFinal>python visual.py
User Instructions
Please choose and enter as following:
Enter 1 to plot a line graph of lengths vs upper velocity,lower velocity and lower Pressure
Enter 2 to plot a line graph of upper diameter vs upper velocity,lower velocity and lower Pressure
Enter 3 to plot a line graph of lower diameter vs upper velocity,lower velocity and lower Pressure
Enter 4 to plot a line graph of lower diameter vs upper velocity,lower velocity and lower Pressure
Enter 5 to plot a line graph of lower diameter vs upper velocity,lower velocity and lower Pressure
Enter a number here : 1
33°C Rain
1:14 PM
7/28/2021

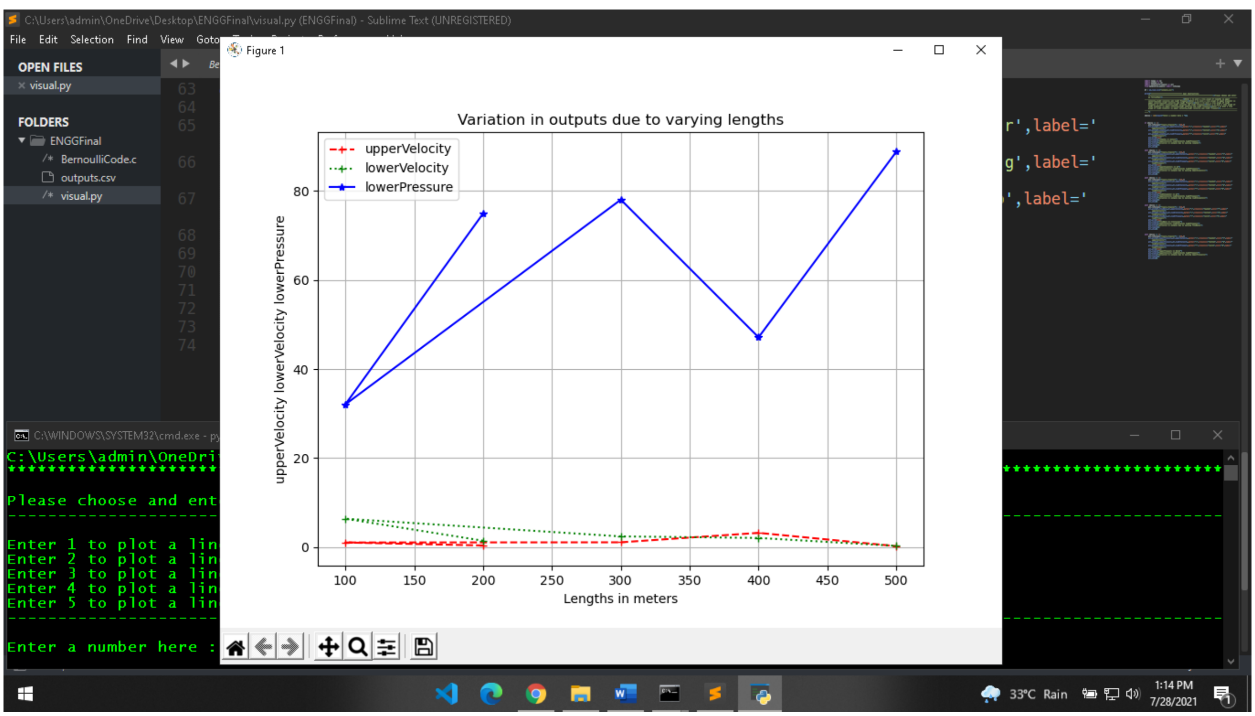


Figure 1
Variation in outputs due to varying lengths
upperVelocity
lowerVelocity
lowerPressure
upperVelocity lowerVelocity lowerPressure
Lengths in meters
0
20
40
60
80
100
150
200
250
300
350
400
450
500
1:14 PM
7/28/2021

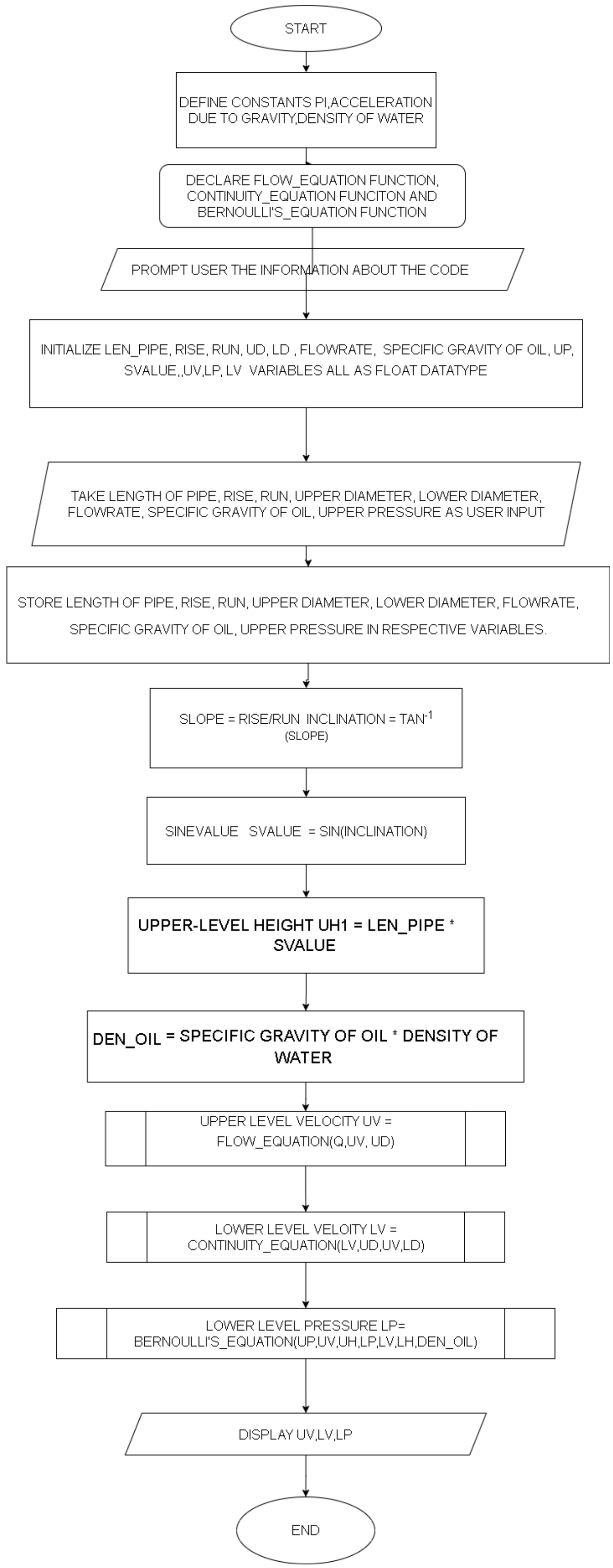
ALGORITHM:

1. START
2. DEFINE CONSTANT VALUSES PI, ACCELERATION DUE TO GRAVITY, DENSITY OF WATER
3. DECLARE FLOW_EQUATION FUNCITON TAKING FLOW RATE , UPPER DIAMETER AND UPPER VELOCITY AS ARGUMENT, CONTINUITY_EQUATION FUNCTION TAKING UPPER_DIAMETER, UPPER VELOCITY, LOWER DIAMETER AND LOWER VELOCITYAS ARGUMENT AND BERNOULLI'S_ EQUATION FUNCTION TAKING UPPER PRESSURE, DENSITY OF OIL, UPPER HEIGHT, LOWER PRESSURE, LOWER VELOCITY AND LOWER HEIGHT AS ARGUMENT AS FLOAT DATATYPE
4. PROMPT USER THE INFORMATION ABOUT THE CODE
5. INITIALIZE LENGTH OF PIPE, RISE, RUN, UPPER DIAMETER, LOWER DIAMETER, FLOWRATE, SPECIFIC GRAVITY OF OIL, UPPER PRESSURE VARIABLES ALL AS FLOAT DATATYPE
6. TAKE LENGTH OF PIPE, RISE, RUN, UPPER DIAMETER, LOWER DIAMETER, FLOWRATE, SPECIFIC GRAVITY OF OIL, UPPER PRESSURE AS USER INPUT

7. STORE LENGTH OF PIPE, RISE, RUN, UPPER DIAMETER, LOWER DIAMETER, FLOWRATE, SPECIFIC GRAVITY OF OIL, UPPER PRESSURE IN RESPECTIVE VARIABLES.
8. CALCULATE SLOPE = $\frac{RISE}{RUN}$, INCLINATION Ɵ = TAN^{-1}(SLOPE) AND STORE IN SLOPE AND INCLINATION VARIABLES OF FLOAT DATATYPE
9. CALCULATE SINE VALUE OF INCLINATION SVALUE = SINE(INCLINATION) AND STORE IN SVALUE VARIABLE OF FLOAT DATATYPE
10. CALCULATE UPPER-LEVEL HEIGHT UH1 = LENGTH * SVALUE AND STORE IN UH1VARIABLE OF FLOAT DATATYPE
11. CALCULATE DENSITY OF OIL DEN_OIL = SPECIFIC GRAVITY OF OIL * DENSITY OF WATER AND STORE IN DEN_OIL VARIABLE OF FLOAT DATATYPE
12. CALCULATE UPPER-LEVEL VELOCITY UV = $\frac{4*Q}{\pi*(D1)2}$ USING FLOW RATE EQUATION FUNCITON AND STORE IN UV1VARIABLE OF FLOAT DATATYPE

13. CALCULATE LOWER-LEVEL VELOCITY LV = $\frac{(D1)2*V1}{(D2)2}$ USING CONTINUTITY EQUATION FUNCTION AND STORE IN LV VARIABLE OF FLOAT DATATYPE
14. CALCULATE LOWER- LEVEL PRESSURE APPLYING BERNAOULLI'S EQUATION FUNCTIN AND STORE IN LP VARIABLE OF FLOAT DATATYPE
15. DISPLAY UPPER- LEVEL VELOCITY, LOWER- LEVEL VELOCITY AND LOWER- LEVEL PRESSURE
16. END.

FLOWCHART:


START
DEFINE CONSTANTS PI,ACCELERATION DUE TO GRAVITY,DENSITY OF WATER
DECLARE FLOW_EQUATION FUNCTION, CONTINUITY_EQUATION FUNCITON AND BERNOULLI'S_EQUATION FUNCTION
PROMPT USER THE INFORMATION ABOUT THE CODE
INITIALIZE LEN_PIPE, RISE, RUN, UD, LD , FLOWRATE, SPECIFIC GRAVITY OF OIL, UP, SVALUE,,UV,LP, LV VARIABLES ALL AS FLOAT DATATYPE
TAKE LENGTH OF PIPE, RISE, RUN, UPPER DIAMETER, LOWER DIAMETER, FLOWRATE, SPECIFIC GRAVITY OF OIL, UPPER PRESSURE AS USER INPUT
STORE LENGTH OF PIPE, RISE, RUN, UPPER DIAMETER, LOWER DIAMETER, FLOWRATE, SPECIFIC GRAVITY OF OIL, UPPER PRESSURE IN RESPECTIVE VARIABLES.
SLOPE = RISE/RUN INCLINATION = TAN^{-1} (SLOPE)
SINEVALUE SVALUE = SIN(INCLINATION)
UPPER-LEVEL HEIGHT UH1 = LEN_PIPE * SVALUE
DEN_OIL = SPECIFIC GRAVITY OF OIL * DENSITY OF WATER
UPPER LEVEL VELOCITY UV = FLOW_EQUATION(Q,UV, UD)
LOWER LEVEL VELOITY LV = CONTINUITY_EQUATION(LV,UD,UV,LD)
LOWER LEVEL PRESSURE LP= BERNOULLI'S_EQUATION(UP,UV,UH,LP,LV,LH,DEN_OIL)
DISPLAY UV,LV,LP
END

EXPECTED OUTCOMES:

The reference problem statement was solved in 4 different scenarios using a computer program that was written in C language. While solving 4 cases in the proposal paper, a normal scientific calculator was used which can give up to 9 places of decimal. When we used the computer program we got more precise values. Thus slightly different values were encountered which was supposed to happen. So percentage error was calculated and analyzed. As we dealt with multiple inputs for the same data calculating percentage error for each data and a new error for every time was cumbersome. So here a simple formula to calculate the percentage error is displayed and is used to calculate percentage error for one case.

Percentage error $\delta = \left|\frac{\upsilon A - \upsilon E}{\upsilon E}\right| * 100\ \%$

Where,

υA = actual value observed

υE = expected value

δ = percentage error

For refrence case,

Lower pressure = 74.92 KN/m^2 = υE

Which is observed using scientific calculator

With C program

Lower pressure = 74.945477 $KN/\ m^2$ = υA

Then as per the formula,

Percentage error = $\left|\frac{74.945477 - 74.92}{74.92}\right| * 100\% = 0.03401\%$

Looking at the percentage error, its so minimum that its almost insignificant.

REFERENCES:

[1] Wikipedia.com, Article on Bernoulli's theorem, link to article - Bernoulli's principle - Wikipedia

[2] Byjus.com, Article on Bernoulli's theorem, link to article - Bernoulli's Principle & Bernoulli Equation - Definition, Derivation, Principle of Continuity, Applications, Examples and FAQs (byjus.com)