cfd-assignment

February 5, 2023

1 Question

As discussed in the tutorial class, you have to submit a CFD coding assignment for a fully developed flow through a long rectangular duct with pressure gradient of -1, and dynamic viscosity of 0.001 unit. Write a code by discritizing the domain in 5×5, 25×25, 50×50 mesh sizes and compare the velocity at the middle point. Assume no slip bc at the walls.

1.1 Solution

Boundary condition is no-slip at the walls.

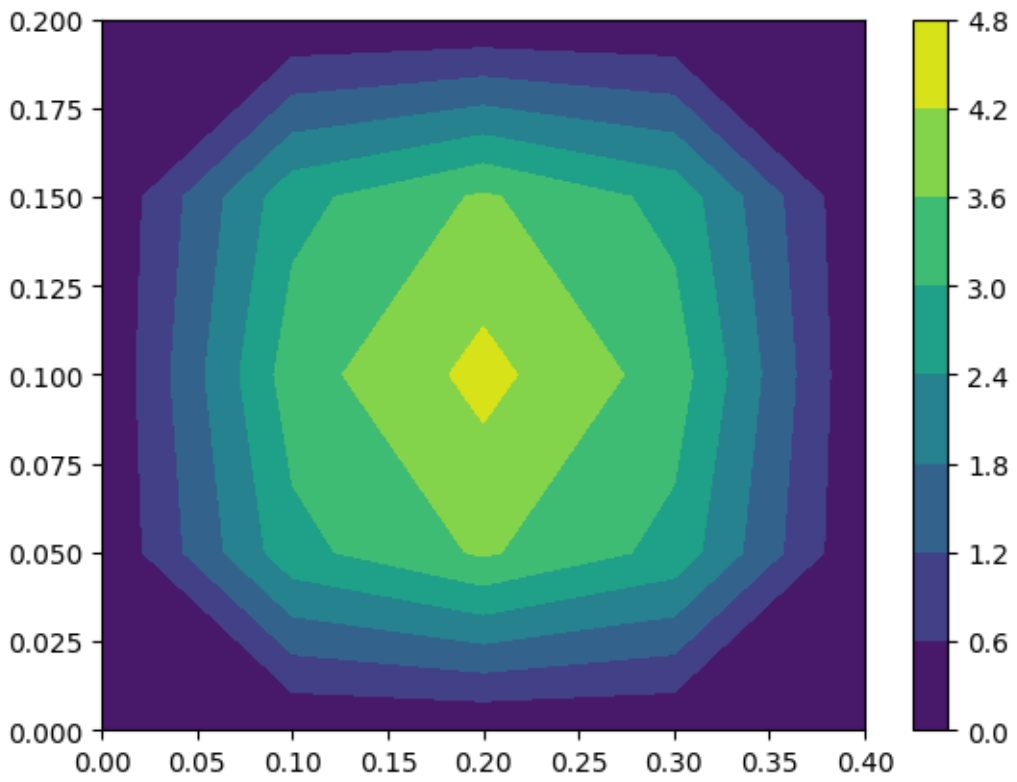
Initial condition is considered as zero matrix.

2 5x5 Matrix

[5]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

dx = 0.1
dy = 0.05
n=5
x_len=n*dx-dx
y_len=n*dy-dy
x = np.arange(0, x_len + dx, dx)
y = np.arange(0, y_len + dy, dy)

bc = [0, 0]
n = len(x)
m = len(y)
w = np.zeros((n, m))
w[0, :] = bc[0]
w[0, :] = bc[0]
w[:, 0] = bc[0]
w[:, 0] = bc[0]

f = (dx**2)/(dy**2)
```

```
k = 1
while k>0.0001:
    temp=w[2,2]
    for j in range(1, m - 1):
        for i in range(1, n - 1):
            w[i, j] = (1/(2 +(2*f))) * (w[i + 1, j] + w[i - 1, j] +(f*w[i,␣
 ↪j+1]) + (f*w[i, j-1]) + 10)
    k=abs(w[2,2]-temp)

# print("The calculated value of w at each mesh points are: ")
# print(w)

print("The velocity of middle point is: ")
print(w[2,2])

plt.contourf(x, y, w)
plt.colorbar()
# plt.title('5by5')
# plt.xlabel('x')
# plt.ylabel('y')
# plt.savefig('contour.png', dpi=300)
plt.show()

# data = pd.DataFrame(w)
# data.to_csv("5by5(output).csv")
```

```
The velocity of middle point is:
4.390148535009508
```

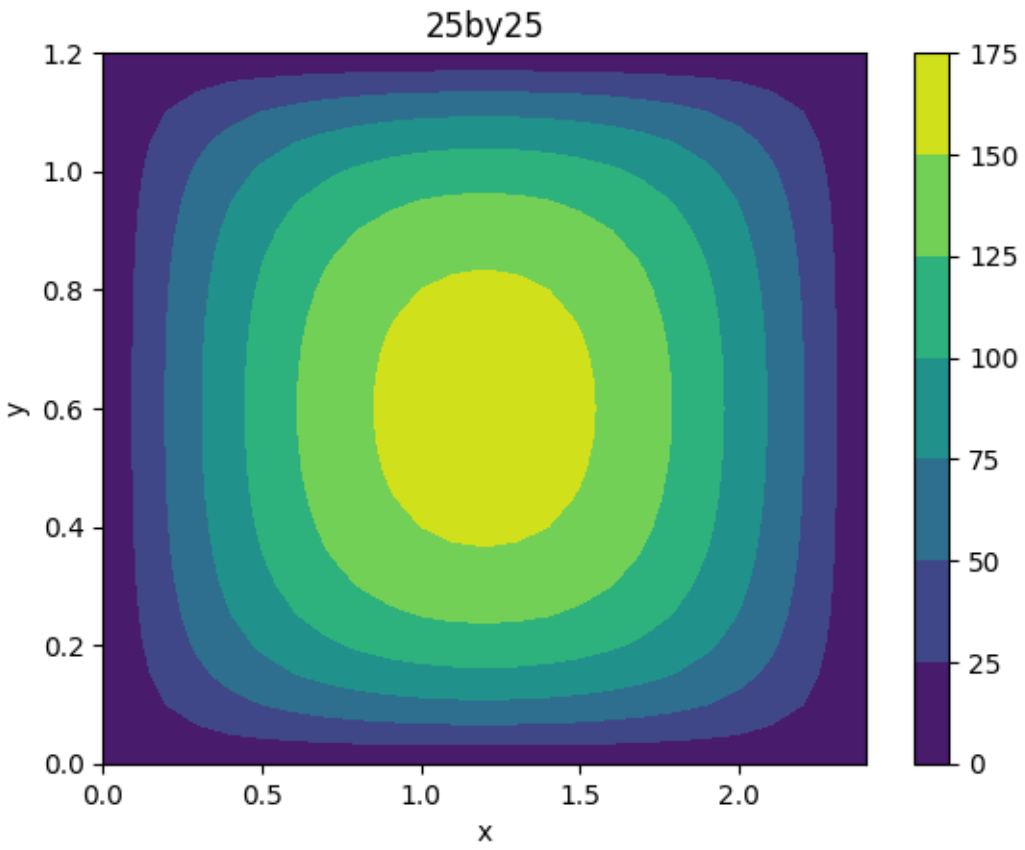


2.1 25x25 Matrix

[6]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

dx = 0.1
dy = 0.05
n=25
x_len=n*dx-dx
y_len=n*dy-dy
x = np.arange(0, x_len + dx, dx)
y = np.arange(0, y_len + dy, dy)

bc = [0, 0]
n = len(x)
m = len(y)
w = np.zeros((n, m))
w[0, :] = bc[0]
w[0, :] = bc[0]
w[:, 0] = bc[0]
w[:, 0] = bc[0]
```

```
f = (dx**2)/(dy**2)

k = 1
while k>0.0001:
    temp=w[2,2]
    for j in range(1, m - 1):
        for i in range(1, n - 1):
            w[i, j] = (1/(2 +(2*f))) * (w[i + 1, j] + w[i - 1, j] +(f*w[i,j+1]) + (f*w[i, j-1]) + 10)
    k=abs(w[2,2]-temp)

# print("The calculated value of w at each mesh points are: ")
# print(w)

print("The velocity of middle point is: ")
print(w[12,12])

plt.contourf(x, y, w)
plt.title('25by25')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.show()

# data = pd.DataFrame(w)
# data.to_csv("25by25(output).csv")
```

```
The velocity of middle point is:
163.72456540712452
```

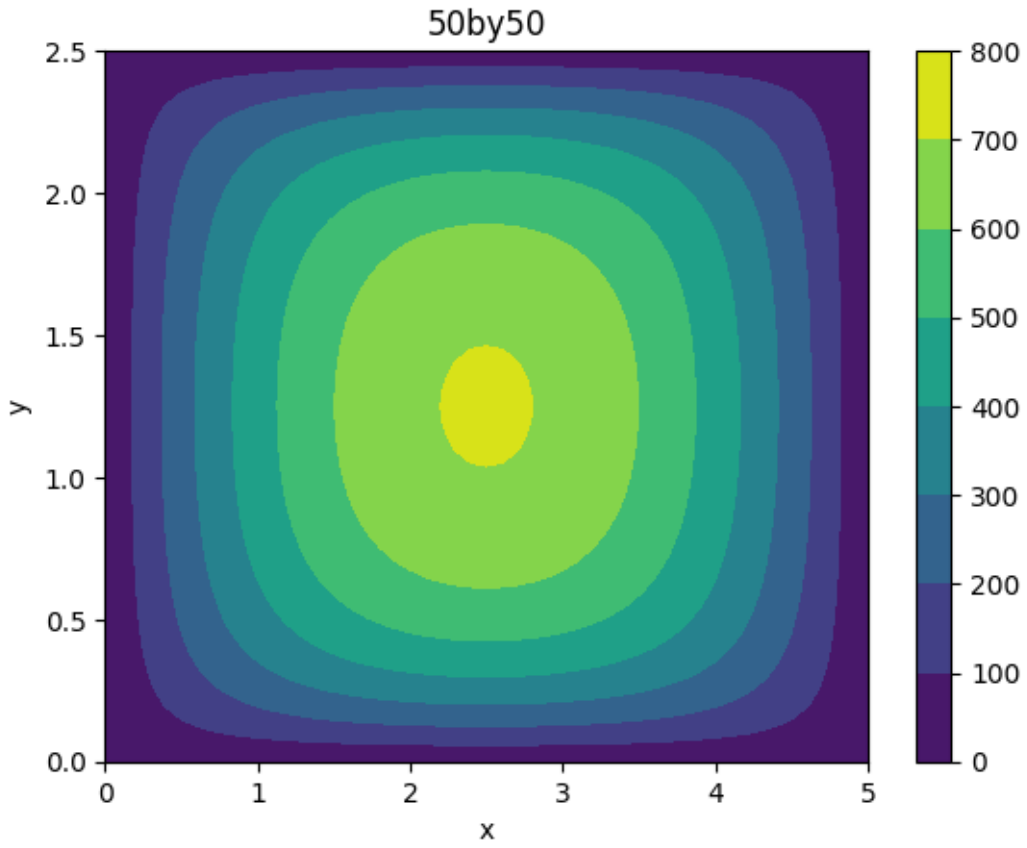


2.2 50x50 Matrix

[7]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

dx = 0.1
dy = 0.05
n=51
x_len=n*dx-dx
y_len=n*dy-dy
x = np.arange(0, x_len + dx, dx)
y = np.arange(0, y_len + dy, dy)

bc = [0, 0]
n = len(x)
m = len(y)
w = np.zeros((n, m))
w[0, :] = bc[0]
w[0, :] = bc[0]
```

```
w[:, 0] = bc[0]
w[:, 0] = bc[0]

f = (dx**2)/(dy**2)

k = 1
while k>0.0001:
    temp=w[2,2]
    for j in range(1, m - 1):
        for i in range(1, n - 1):
            w[i, j] = (1/(2 +(2*f))) * (w[i + 1, j] + w[i - 1, j] +(f*w[i,
 ↪j+1]) + (f*w[i, j-1]) + 10)
    k=abs(w[2,2]-temp)

# print("The calculated value of w at each mesh points are: ")
# print(w)

print("The velocity of middle point is: ")
print(w[25,25])

plt.contourf(x, y, w)
plt.title('50by50')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.show()

# data = pd.DataFrame(w)
# data.to_csv("50by50(output).csv")
```

```
The velocity of middle point is:
710.0531245210392
```



2.3 The velocity at the middle point of the 5x5, 25x25, and 50x50 are 4.390148535009508, 163.72456540712452, and 710.0531245210392