Numerical Techniques Laboratory

Assignment Upwind Scheme | Tanishq Jasoria | 16MA20047

Solve the PDE

$$\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$$

for the boundary conditions

$$\mathrm{u}(x,0) = \begin{cases} 20x & 0 \le x \le 0.05 \\ 20(0.1 - x) & 0.05 \le x \le 0.1 \\ 0 & \text{otherwise} \end{cases}$$

Choose c = 1 Since we have chose $c > 0$ so Forward Time Forward Space Discretization is used.

$$u_j^{n+1} = (1 - \nu)u_j^n + \nu u_{j-1}^n$$

$$\text{where } \nu = c\frac{\partial t}{\partial x}$$

In [1]:

```
import numpy as np
from matplotlib import pyplot as plt
from mpl_toolkits import mplot3d
from copy import copy

%matplotlib inline
plt.rcParams['figure.figsize'] = [10, 10]
```

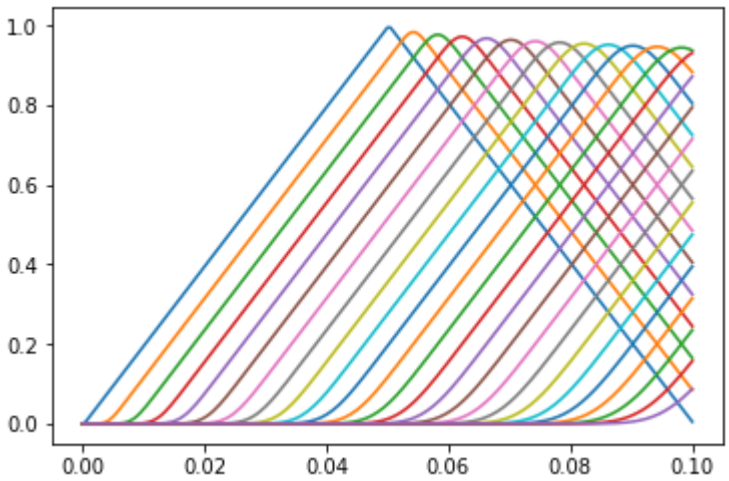
In [2]:

```
# Initialize the solution for t = 0
def initialize(space_step):
    number = np.ceil(0.5/space_step) + 1
    u_ = 20*np.linspace(0, 0.05, number)
    u_ = u_[:-1]
    u = np.append(u_, 20*np.linspace(0.05, 0, number))
    return u

def upwind(c, u_prev, space_step, time_step):
    nu = c*(time_step/space_step)
    u = np.zeros((u_prev.shape[0]))
    u[0] = 0
    for i in range(1, u_prev.shape[0]):
        u[i] = (1 - nu)*u_prev[i] +  nu*u_prev[i-1]
#     print(u)
    return u
```

In [3]:

```
space_step = 0.005
time_step = 0.0025
x = np.linspace(0, 0.1, 1/space_step + 1)
u_init = initialize(space_step)
t = 1
time_steps = int(np.ceil(t/time_step)+1)
time_step_print = [int(time_steps*i/25) for i in range(25)]
print(time_step_print)
for i in range(time_steps):
    u_new = upwind(1, u_init, space_step, time_step )
    if i in time_step_print:
        plt.plot(x, u_new)
    u_init = u_new
```

```
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:3: Deprec
ationWarning: object of type <class 'float'> cannot be safely interpre
ted as an integer.
  This is separate from the ipykernel package so we can avoid doing im
ports until
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:4: Deprec
ationWarning: object of type <class 'numpy.float64'> cannot be safely
interpreted as an integer.
  after removing the cwd from sys.path.
/usr/local/lib/python3.6/dist-packages/ipykernel_launcher.py:6: Deprec
ationWarning: object of type <class 'numpy.float64'> cannot be safely
interpreted as an integer.


[0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, 24
0, 256, 272, 288, 304, 320, 336, 352, 368, 384]
```



In [ ]:

In [ ]: