# Numerical Techniques Laboratory

## Assignment 3 | Tanishq Jasoria | 16MA20047

Solve the following differential equation -

y''' + 4y'' + y' - 6y = 1

y(0) = y'(0) = 0

y'(1) = 1

In [29]:

```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
%matplotlib inline
plt.rcParams['figure.figsize'] = [10, 15]
```

In [30]:

```
def BlockTridiagonal(A, B, C, D):
    n = len(D)
    _B = np.zeros(A.shape)
    _C = np.zeros(A.shape)
    _D = np.zeros((n,2,1))
    D_out = np.zeros(_D.shape)
    _C[0] = np.linalg.inv(B[0]).dot(C[0])
    _D[0] = np.linalg.inv(B[0]).dot(D[0])

    for i in range(1, n):
        _B[i] = B[i] - A[i].dot(_C[i-1])
        _C[i] = np.linalg.inv(_B[i]) .dot(C[i])
        _D[i] = np.linalg.inv(_B[i]).dot(D[i] - A[i].dot(_D[i-1]))
    D_out[n-1] = np.copy(_D[n-1])
    for i in range(n-2, -1, -1):
        D_out[i] = _D[i] - _C[i].dot(D_out[i+1])

    return D_out
```

In [31]:

```
def BVP(x0, xn, h):
    n = int(np.ceil((xn - x0)/h))

    A = np.zeros((n-1, 2, 2))
    B = np.zeros((n-1, 2, 2))
    C = np.zeros((n-1, 2, 2))
    D = np.zeros((n-1, 2, 1))
    for i in range(n-1):
        A[i] = np.array([[-1, -h/2], [0, 1/h**2 - 2/h]])
        B[i] = np.array([[1, -h/2], [-6, -2/h**2 + 1]])
        C[i] = np.array([[0, 0], [0, 1/h**2 + 2/h]])
        D[i] = np.array([[0], [1]])

    D[n-2] = D[n-2] - np.array([[0], [1/h**2 + 2/h]])
    X = BlockTridiagonal(A, B, C, D)
    y = X[:, 0]

    y = np.reshape(y, n-1)
    print(y.shape)
#     print(y)
#     y = np.append(y, ((1/h - 1/h**2 + 4/h - 3*X[n-2, 1]/h**2)/6))
    print(y)
#     print(A)
#     print(B)
#     print(C)
#     print(D)
    return y
```

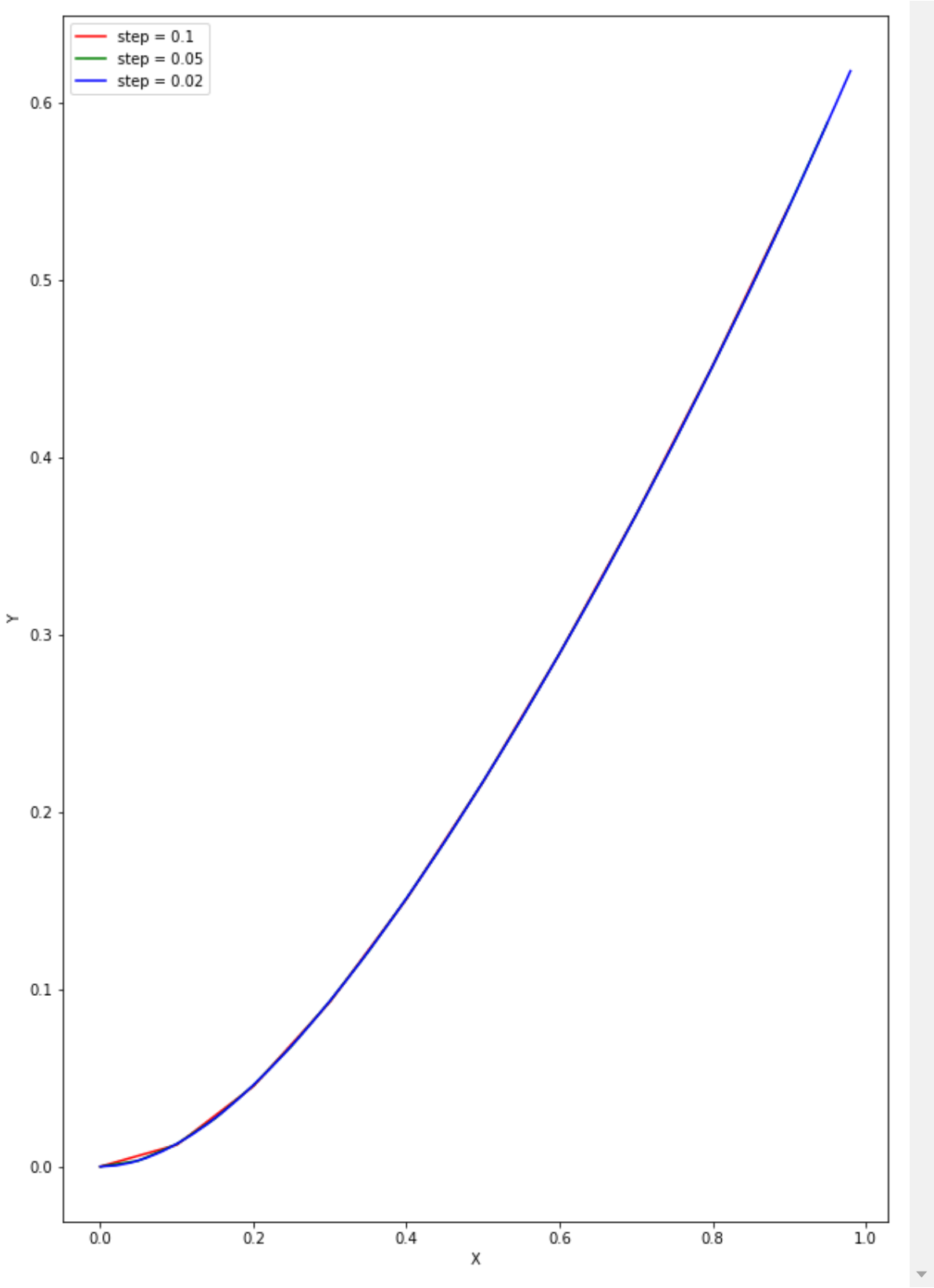
In [32]:

```
def func(x0, xn, h = 0.1):
    return np.arange(x0, xn, h)
steps = [0.1, 0.05, 0.02]
colors = ['r', 'g', 'b']
x0 = 0
xn = 1
labels = ["step = 0.1", "step = 0.05", "step = 0.02"]
for step in steps:
    x_range = func(x0, xn, step)
    print(x_range)
    print("Shape of x_range")
    print(x_range.shape)
    y = BVP(x0, xn, step)

    y = np.insert(y, 0, 0)
    print(y.shape)
    print(y)
    plt.xlabel('X')
    plt.ylabel('Y')
    i = steps.index(step)
    plt.plot( x_range, y, colors[i])
    plt.savefig("Plot.png")
    plt.gca().legend(labels)
```

```
[0.  0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9]
Shape of x_range
(10,)
(9,)
[0.01224889 0.04525781 0.09280878 0.15083668 0.2168081  0.28927787
 0.3675745  0.45157872 0.54156916]
(10,)
[0.         0.01224889 0.04525781 0.09280878 0.15083668 0.2168081
 0.28927787 0.3675745  0.45157872 0.54156916]
[0.   0.05 0.1  0.15 0.2  0.25 0.3  0.35 0.4  0.45 0.5  0.55 0.6  0.65
 0.7  0.75 0.8  0.85 0.9  0.95]
Shape of x_range
(20,)
(19,)
[0.00330832 0.01268219 0.02711657 0.04578576 0.06801587 0.09326135
 0.1210852  0.1511421  0.18316417 0.21694893 0.25234915 0.28926427
 0.32763325 0.36742848 0.40865079 0.45132524 0.49549761 0.54123159
 0.58860637]
(20,)
[0.         0.00330832 0.01268219 0.02711657 0.04578576 0.06801587
 0.09326135 0.1210852  0.1511421  0.18316417 0.21694893 0.25234915
 0.28926427 0.32763325 0.36742848 0.40865079 0.45132524 0.49549761
 0.54123159 0.58860637]
[0.   0.02 0.04 0.06 0.08 0.1  0.12 0.14 0.16 0.18 0.2  0.22 0.24 0.26
 0.28 0.3  0.32 0.34 0.36 0.38 0.4  0.42 0.44 0.46 0.48 0.5  0.52 0.54
 0.56 0.58 0.6  0.62 0.64 0.66 0.68 0.7  0.72 0.74 0.76 0.78 0.8  0.82
 0.84 0.86 0.88 0.9  0.92 0.94 0.96 0.98]
Shape of x_range
(50,)
(49,)
[5.56802095e-04 2.18802230e-03 4.81814132e-03 8.37716319e-03
 1.28002618e-02 1.80274496e-02 2.40032667e-02 3.06764902e-02
 3.79998609e-02 4.59298280e-02 5.44263094e-02 6.34524674e-02
 7.29744986e-02 8.29614373e-02 9.33849710e-02 1.04219268e-01
 1.15440817e-01 1.27028275e-01 1.38962325e-01 1.51225548e-01
```

```
  1.63802294e-01 1.76678572e-01 1.89841938e-01 2.03281395e-01
  2.16987302e-01 2.30951281e-01 2.45166139e-01 2.59625791e-01
  2.74325186e-01 2.89260242e-01 3.04427787e-01 3.19825494e-01
  3.35451837e-01 3.51306030e-01 3.67387990e-01 3.83698289e-01
  4.00238114e-01 4.17009230e-01 4.34013948e-01 4.51255089e-01
  4.68735958e-01 4.86460312e-01 5.04432342e-01 5.22656640e-01
  5.41138188e-01 5.59882330e-01 5.78894757e-01 5.98181492e-01
  6.17748871e-01]
 (50,)
 [0.00000000e+00 5.56802095e-04 2.18802230e-03 4.81814132e-03
  8.37716319e-03 1.28002618e-02 1.80274496e-02 2.40032667e-02
  3.06764902e-02 3.79998609e-02 4.59298280e-02 5.44263094e-02
  6.34524674e-02 7.29744986e-02 8.29614373e-02 9.33849710e-02
  1.04219268e-01 1.15440817e-01 1.27028275e-01 1.38962325e-01
  1.51225548e-01 1.63802294e-01 1.76678572e-01 1.89841938e-01
  2.03281395e-01 2.16987302e-01 2.30951281e-01 2.45166139e-01
  2.59625791e-01 2.74325186e-01 2.89260242e-01 3.04427787e-01
  3.19825494e-01 3.35451837e-01 3.51306030e-01 3.67387990e-01
  3.83698289e-01 4.00238114e-01 4.17009230e-01 4.34013948e-01
  4.51255089e-01 4.68735958e-01 4.86460312e-01 5.04432342e-01
  5.22656640e-01 5.41138188e-01 5.59882330e-01 5.78894757e-01
  5.98181492e-01 6.17748871e-01]
```




In [ ]: