

MA322 Scientific Computing lab: 07

Name: Naman Goyal

Roll No. 180123029

- To execute my .py file
Run `$python3 180123029_NamanGoyal.py` on the terminal. Screenshots are attached question-wise

Ques.1

```
~ /Desktop/IITG_SEMVI/sci_lab/lab07
python3 180123029_NamanGoyal.py
-----Q1-----
Units of KOH at t = 0.2s is 2080.0569
-----
```

Ques.2

A pdf file is attached here with it for the proof for Modified Euler Function.

```
-----Q2-----
h = 0.10
Runge-Kutta Method: y(0.00) = 1.000000
Modified Euler Method: y(0.00) = 1.000000

Runge-Kutta Method: y(0.10) = 1.005000
Modified Euler Method: y(0.10) = 1.005000

Runge-Kutta Method: y(0.20) = 1.019025
Modified Euler Method: y(0.20) = 1.019025

Runge-Kutta Method: y(0.30) = 1.041218
Modified Euler Method: y(0.30) = 1.041218

Runge-Kutta Method: y(0.40) = 1.070802
Modified Euler Method: y(0.40) = 1.070802

Runge-Kutta Method: y(0.50) = 1.107076
Modified Euler Method: y(0.50) = 1.107076

Runge-Kutta Method: y(0.60) = 1.149404
Modified Euler Method: y(0.60) = 1.149404

Runge-Kutta Method: y(0.70) = 1.197210
Modified Euler Method: y(0.70) = 1.197210

Runge-Kutta Method: y(0.80) = 1.249975
Modified Euler Method: y(0.80) = 1.249975

Runge-Kutta Method: y(0.90) = 1.307228
Modified Euler Method: y(0.90) = 1.307228

Runge-Kutta Method: y(1.00) = 1.368541
Modified Euler Method: y(1.00) = 1.368541
```

```
h = 0.20
Runge-Kutta Method: y(0.00) = 1.000000
Modified Euler Method: y(0.00) = 1.000000

Runge-Kutta Method: y(0.20) = 1.020000
Modified Euler Method: y(0.20) = 1.020000

Runge-Kutta Method: y(0.40) = 1.072400
Modified Euler Method: y(0.40) = 1.072400

Runge-Kutta Method: y(0.60) = 1.151368
Modified Euler Method: y(0.60) = 1.151368

Runge-Kutta Method: y(0.80) = 1.252122
Modified Euler Method: y(0.80) = 1.252122

Runge-Kutta Method: y(1.00) = 1.370740
Modified Euler Method: y(1.00) = 1.370740

h = 0.25
Runge-Kutta Method: y(0.00) = 1.000000
Modified Euler Method: y(0.00) = 1.000000

Runge-Kutta Method: y(0.25) = 1.031250
Modified Euler Method: y(0.25) = 1.031250

Runge-Kutta Method: y(0.50) = 1.110352
Modified Euler Method: y(0.50) = 1.110352

Runge-Kutta Method: y(0.75) = 1.226837
Modified Euler Method: y(0.75) = 1.226837

Runge-Kutta Method: y(1.00) = 1.372529
Modified Euler Method: y(1.00) = 1.372529

-----
```

Ques.3

-----Q3-----

Part A ----->

Actual: $y(1.000) = 2.000000$

Calculated; $y(1.000) = 2.000000$

Absolute Error = 0.000000

Relative Error = 0.000000 %

Actual: $y(1.500) = 2.354102$

Calculated; $y(1.500) = 2.354167$

Absolute Error = 0.000065

Relative Error = 0.002748 %

Actual: $y(2.000) = 2.741657$

Calculated; $y(2.000) = 2.741745$

Absolute Error = 0.000088

Relative Error = 0.003199 %

Part B ----->

Actual: $y(1.000) = 2.000000$

Calculated; $y(1.000) = 2.000000$

Absolute Error = 0.000000

Relative Error = 0.000000 %

Actual: $y(1.250) = 1.403199$

Calculated; $y(1.250) = 1.416075$

Absolute Error = 0.012876

Relative Error = 0.917625 %

Actual: $y(1.500) = 1.016410$

Calculated; $y(1.500) = 1.031011$

Absolute Error = 0.014601

Relative Error = 1.436519 %

Actual: $y(1.750) = 0.738010$

Calculated; $y(1.750) = 0.752267$

Absolute Error = 0.014257

Relative Error = 1.931805 %

Actual: $y(2.000) = 0.529687$

Calculated; $y(2.000) = 0.543245$

Absolute Error = 0.013558

Relative Error = 2.559606 %

Ques.4

```
-----Q4-----  
  
Euler Method:  $y(0.1) = 0.655498$   
Runge-Kutta Order 2:  $y(0.1) = 0.657373$   
Runge-Kutta Order 4:  $y(0.1) = 0.657414$   
  
Euler Method:  $y(0.2) = 0.825338$   
Runge-Kutta Order 2:  $y(0.2) = 0.829213$   
Runge-Kutta Order 4:  $y(0.2) = 0.829298$   
  
Euler Method:  $y(0.3) = 1.008933$   
Runge-Kutta Order 2:  $y(0.3) = 1.014939$   
Runge-Kutta Order 4:  $y(0.3) = 1.015070$   
  
Euler Method:  $y(0.4) = 1.205635$   
Runge-Kutta Order 2:  $y(0.4) = 1.213908$   
Runge-Kutta Order 4:  $y(0.4) = 1.214087$   
  
Euler Method:  $y(0.5) = 1.414726$   
Runge-Kutta Order 2:  $y(0.5) = 1.425409$   
Runge-Kutta Order 4:  $y(0.5) = 1.425638$   
  
-----
```

Ques.5

-----Q5-----

Actual: $y(0.0) = 0.500000$
Bashforth: $y(0.0) = 0.500000$
Molton: $y(0.0) = 0.500000$

Actual: $y(0.2) = 0.829299$
Bashforth: $y(0.2) = 0.829299$
Molton: $y(0.2) = 0.829299$

Actual: $y(0.4) = 1.214088$
Bashforth: $y(0.4) = 1.214088$
Molton: $y(0.4) = 1.214088$

Actual: $y(0.6) = 1.648941$
Bashforth: $y(0.6) = 1.648941$
Molton: $y(0.6) = 1.648941$

Actual: $y(0.8) = 2.127230$
Bashforth: $y(0.8) = 2.127312$
Molton: $y(0.8) = 2.127228$

Actual: $y(1.0) = 2.640859$
Bashforth: $y(1.0) = 2.641081$
Molton: $y(1.0) = 2.640856$

Actual: $y(1.2) = 3.179942$
Bashforth: $y(1.2) = 3.180348$
Molton: $y(1.2) = 3.179937$

Actual: $y(1.4) = 3.732400$
Bashforth: $y(1.4) = 3.733060$
Molton: $y(1.4) = 3.732392$

Actual: $y(1.6) = 4.283484$
Bashforth: $y(1.6) = 4.284493$
Molton: $y(1.6) = 4.283472$

Actual: $y(1.8) = 4.815176$
Bashforth: $y(1.8) = 4.816657$
Molton: $y(1.8) = 4.815158$

Actual: $y(2.0) = 5.305472$
Bashforth: $y(2.0) = 5.307584$
Molton: $y(2.0) = 5.305446$

Ques.6

-----Q6-----

Part A ----->

Actual: $y(0.000) = 1.000000$

Calculated; $y(0.000) = 1.000000$

Absolute Error = 0.000000

Relative Error = 0.000000 %

Actual: $y(0.100) = 1.188119$

Calculated; $y(0.100) = 1.188119$

Absolute Error = 0.000000

Relative Error = 0.000004 %

Actual: $y(0.200) = 1.346154$

Calculated; $y(0.200) = 1.346154$

Absolute Error = 0.000000

Relative Error = 0.000018 %

Actual: $y(0.300) = 1.467890$

Calculated; $y(0.300) = 1.467889$

Absolute Error = 0.000001

Relative Error = 0.000039 %

Actual: $y(0.400) = 1.551724$

Calculated; $y(0.400) = 1.551743$

Absolute Error = 0.000019

Relative Error = 0.001204 %

Actual: $y(0.500) = 1.600000$

Calculated; $y(0.500) = 1.600397$

Absolute Error = 0.000397

Relative Error = 0.024795 %

Actual: $y(0.600) = 1.617647$
Calculated; $y(0.600) = 1.618496$
Absolute Error = 0.000849
Relative Error = 0.052474 %

Actual: $y(0.700) = 1.610738$
Calculated; $y(0.700) = 1.611961$
Absolute Error = 0.001223
Relative Error = 0.075927 %

Actual: $y(0.800) = 1.585366$
Calculated; $y(0.800) = 1.586785$
Absolute Error = 0.001419
Relative Error = 0.089493 %

Actual: $y(0.900) = 1.546961$
Calculated; $y(0.900) = 1.548412$
Absolute Error = 0.001451
Relative Error = 0.093775 %

Actual: $y(1.000) = 1.500000$
Calculated; $y(1.000) = 1.501366$
Absolute Error = 0.001366
Relative Error = 0.091046 %

Part B ----->

Actual: $y(1.000) = -1.442695$
Calculated; $y(1.000) = -1.442695$
Absolute Error = 0.000000
Relative Error = 0.000000 %

Actual: $y(1.100) = -1.347823$
Calculated; $y(1.100) = -1.347823$
Absolute Error = 0.000000
Relative Error = 0.000002 %

Actual: $y(1.200) = -1.268299$
Calculated; $y(1.200) = -1.268299$
Absolute Error = 0.000000
Relative Error = 0.000004 %

Actual: $y(1.300) = -1.200611$
Calculated; $y(1.300) = -1.200611$
Absolute Error = 0.000000
Relative Error = 0.000005 %

Actual: $y(1.400) = -1.142245$
Calculated; $y(1.400) = -1.142396$
Absolute Error = 0.000151
Relative Error = 0.013192 %

Actual: $y(1.500) = -1.091357$
Calculated; $y(1.500) = -1.091567$
Absolute Error = 0.000210
Relative Error = 0.019266 %

Actual: $y(1.600) = -1.046560$
Calculated; $y(1.600) = -1.046822$
Absolute Error = 0.000262
Relative Error = 0.025065 %

Actual: $y(1.700) = -1.006794$
Calculated; $y(1.700) = -1.007070$
Absolute Error = 0.000276
Relative Error = 0.027377 %

Actual: $y(1.800) = -0.971233$
Calculated; $y(1.800) = -0.971516$
Absolute Error = 0.000284
Relative Error = 0.029207 %

Actual: $y(1.900) = -0.939222$
Calculated; $y(1.900) = -0.939504$
Absolute Error = 0.000282
Relative Error = 0.029976 %

Actual: $y(2.000) = -0.910239$
Calculated; $y(2.000) = -0.910516$
Absolute Error = 0.000277
Relative Error = 0.030450 %

Part C ----->

Actual: $y(1.000) = -2.000000$
Calculated; $y(1.000) = -2.000000$
Absolute Error = 0.000000
Relative Error = 0.000000 %

Actual: $y(1.200) = -1.714286$
Calculated; $y(1.200) = -1.679791$
Absolute Error = 0.034495
Relative Error = 2.012220 %

Actual: $y(1.400) = -1.555556$
Calculated; $y(1.400) = -1.465578$
Absolute Error = 0.089977
Relative Error = 5.784248 %

Actual: $y(1.600) = -1.454545$
Calculated; $y(1.600) = -1.311703$
Absolute Error = 0.142842
Relative Error = 9.820401 %

Actual: $y(1.800) = -1.384615$
Calculated; $y(1.800) = -1.202959$
Absolute Error = 0.181657
Relative Error = 13.119647 %

Actual: $y(2.000) = -1.333333$
Calculated; $y(2.000) = -1.111690$
Absolute Error = 0.221643
Relative Error = 16.623240 %


```
Actual: y(2.200) = -1.294118
Calculated; y(2.200) = -1.040066
Absolute Error = 0.254052
Relative Error = 19.631294 %
```

```
Actual: y(2.400) = -1.263158
Calculated; y(2.400) = -0.977950
Absolute Error = 0.285208
Relative Error = 22.578986 %
```

```
Actual: y(2.600) = -1.238095
Calculated; y(2.600) = -0.926973
Absolute Error = 0.311122
Relative Error = 25.129114 %
```

```
Actual: y(2.800) = -1.217391
Calculated; y(2.800) = -0.882541
Absolute Error = 0.334850
Relative Error = 27.505531 %
```

```
Actual: y(3.000) = -1.200000
Calculated; y(3.000) = -0.844575
Absolute Error = 0.355425
Relative Error = 29.618754 %
```

Ques.7

```
-----Q7-----
Adam Predictor Corrector Method
y(0.0) = 0.500000
y(0.2) = 0.829293
y(0.4) = 1.214076
y(0.6) = 1.648922
y(0.8) = 2.127206
y(1.0) = 2.640829
y(1.2) = 3.179903
y(1.4) = 3.732350
y(1.6) = 4.283421
y(1.8) = 4.815096
y(2.0) = 5.305371
-----
```
