

19101036_assi02_Q1_plots

January 26, 2020

- 1 Q1) Solve and plot the exact and numerical results for $\Delta t = 0.1, 0.6, 2.1$ using Explicit Euler, Implicit Euler, Crank-Nicolson, RK-2, RK-3, RK-3(Williamson) and RK-4 for the ODE $d/dt =$, where $= -1$, with initial value as $(0)=1$.

1.1 Explicit Euler

```
[78]: import csv

with open('explicitEuq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('explicitEuq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('explicitEuq1_2_1.txt') as inf:
    x3 = []
    y3 = []
    for line in csv.reader(inf):
        tx, ty = line
        x3.append(float(tx))
        y3.append(float(ty))
```

```
[79]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pyplot as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
```

```

        'axes.labelsize': 'x-large',
        'axes.titlesize': 'x-large',
        'xtick.labelsize': 'x-large',
        'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

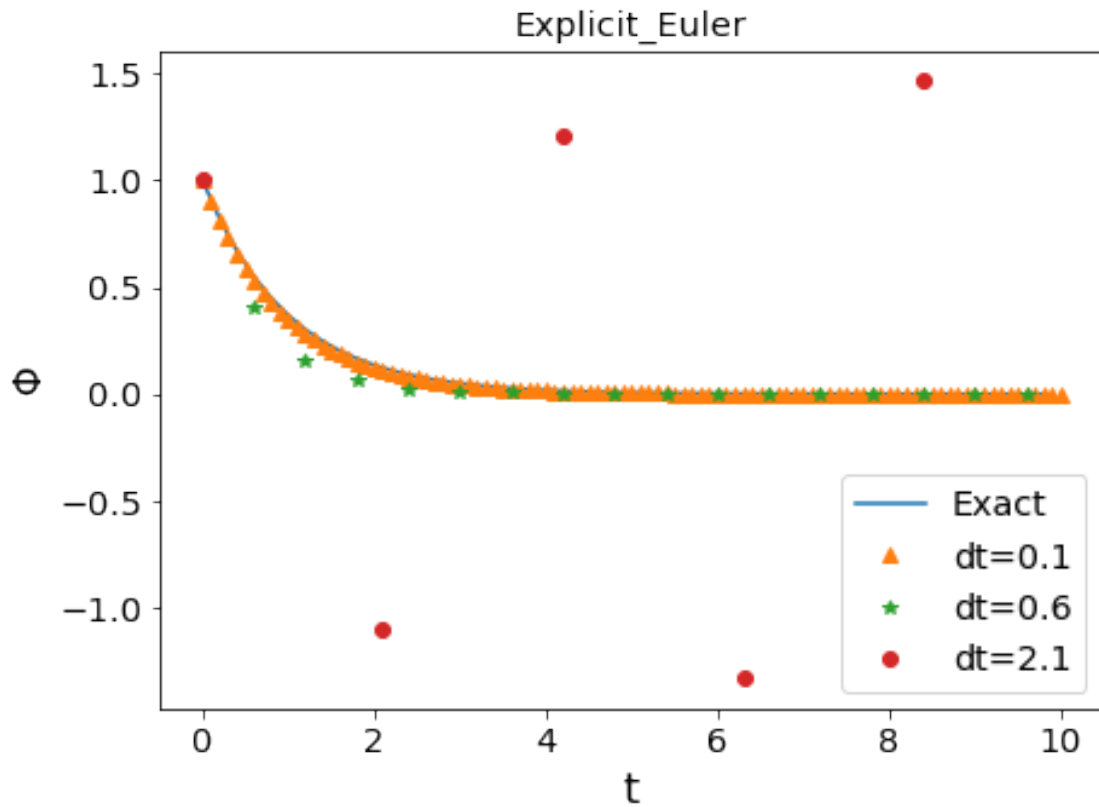
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel('y', fontsize=16)

# Create the plot
plt.plot(tx,ty, '-', label='Exact')
plt.plot(x1,y1, '^', label='dt=0.1')
plt.plot(x2,y2, '*', label='dt=0.6')
plt.plot(x3,y3, 'o', label='dt=2.1')
#x1 = np.arange(0 ,1 ,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1, '^', label='n=1')
# Show the plot
#plt.legend()
plt.title('Explicit_Euler')
plt.gca().legend(('Exact', 'dt=0.1', 'dt=0.6', 'dt=2.1'))
plt.savefig('Explicit_Euler.png')
plt.show()

```



1.2 Implicit Euler

```
[80]: import csv

with open('implicitEuq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('implicitEuq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('implicitEuq1_2_1.txt') as inf:
    x3 = []
```

```

y3 = []
for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[81]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

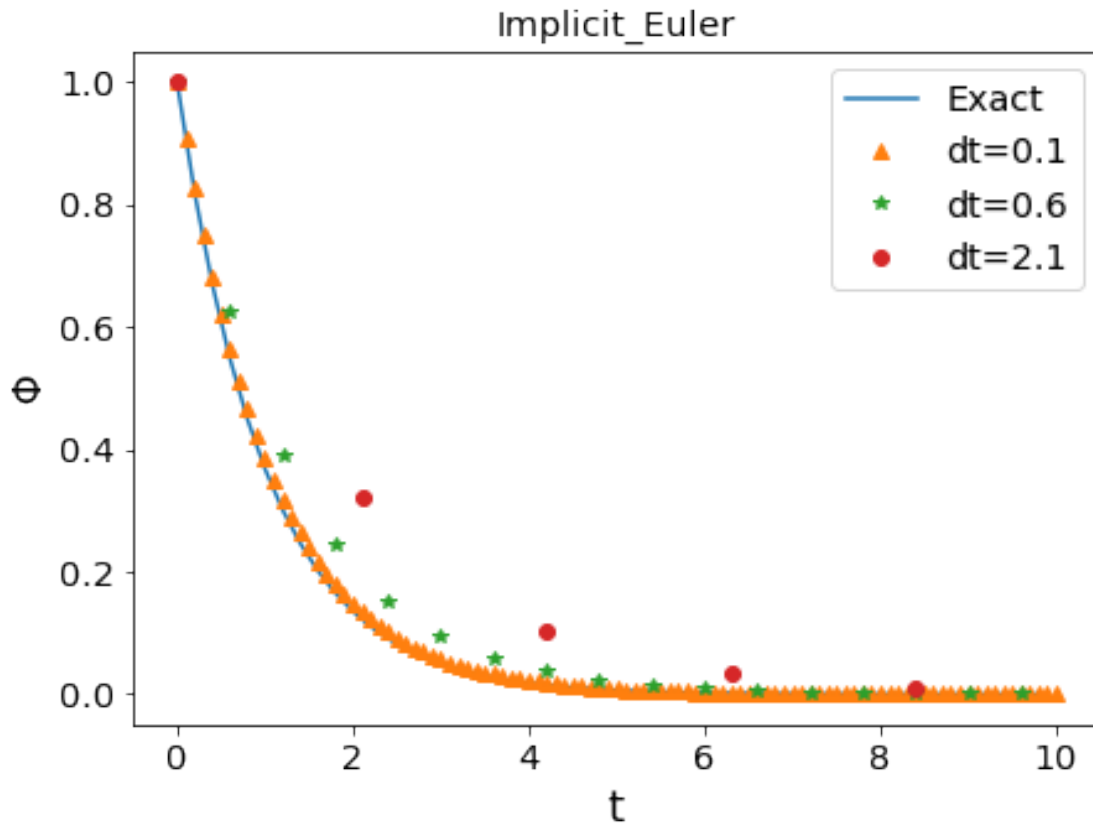
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel(' ', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0,1,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('Implicit_Euler')
plt.gca().legend(('Exact','dt=0.1','dt=0.6','dt=2.1'))
plt.savefig('Implicit_Euler.png')
plt.show()

```



1.3 Crank-Nicolson

```
[82]: import csv

with open('cnEuq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('cnEuq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('cnEuq1_2_1.txt') as inf:
    x3 = []
```

```

y3 = []
for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[83]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

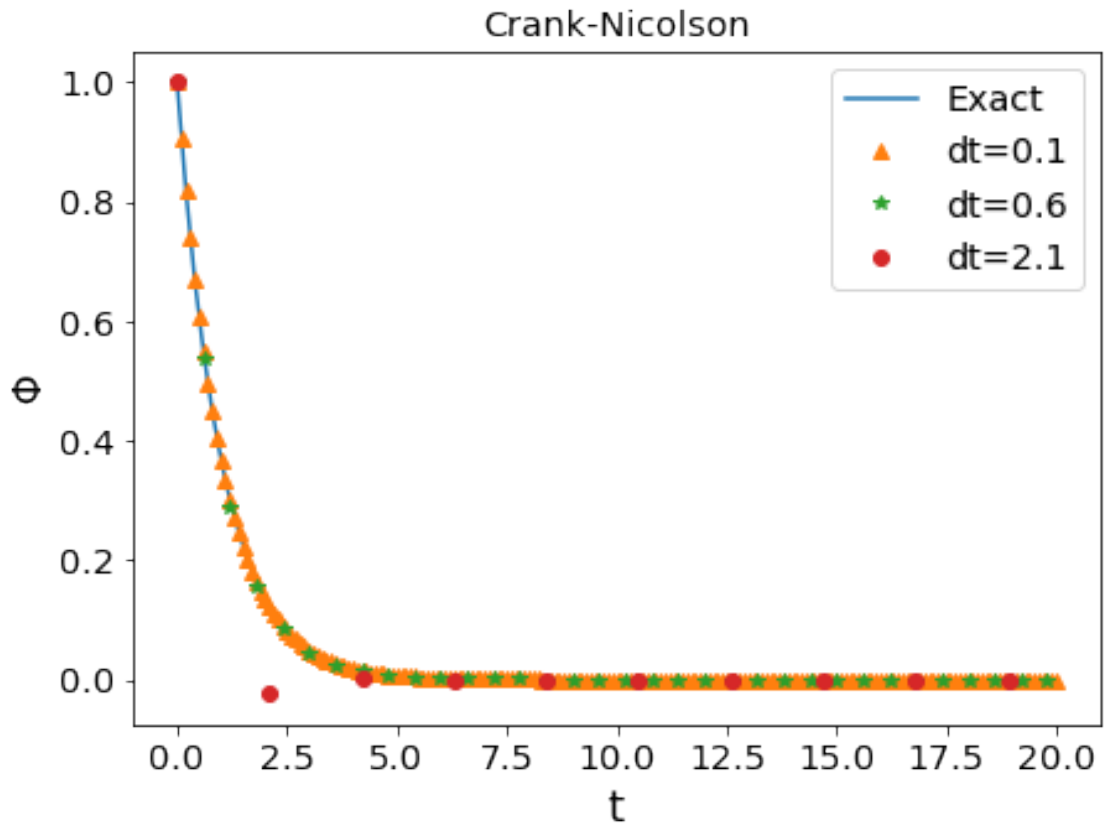
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel(' ', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0,1,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('Crank-Nicolson')
plt.gca().legend(('Exact','dt=0.1','dt=0.6','dt=2.1'))
plt.savefig('Crank-Nicolson.png')
plt.show()

```



1.4 RK-2

```
[84]: import csv

with open('rk2Euq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('rk2Euq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('rk2Euq1_2_1.txt') as inf:
    x3 = []
```

```

y3 = []
for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[85]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

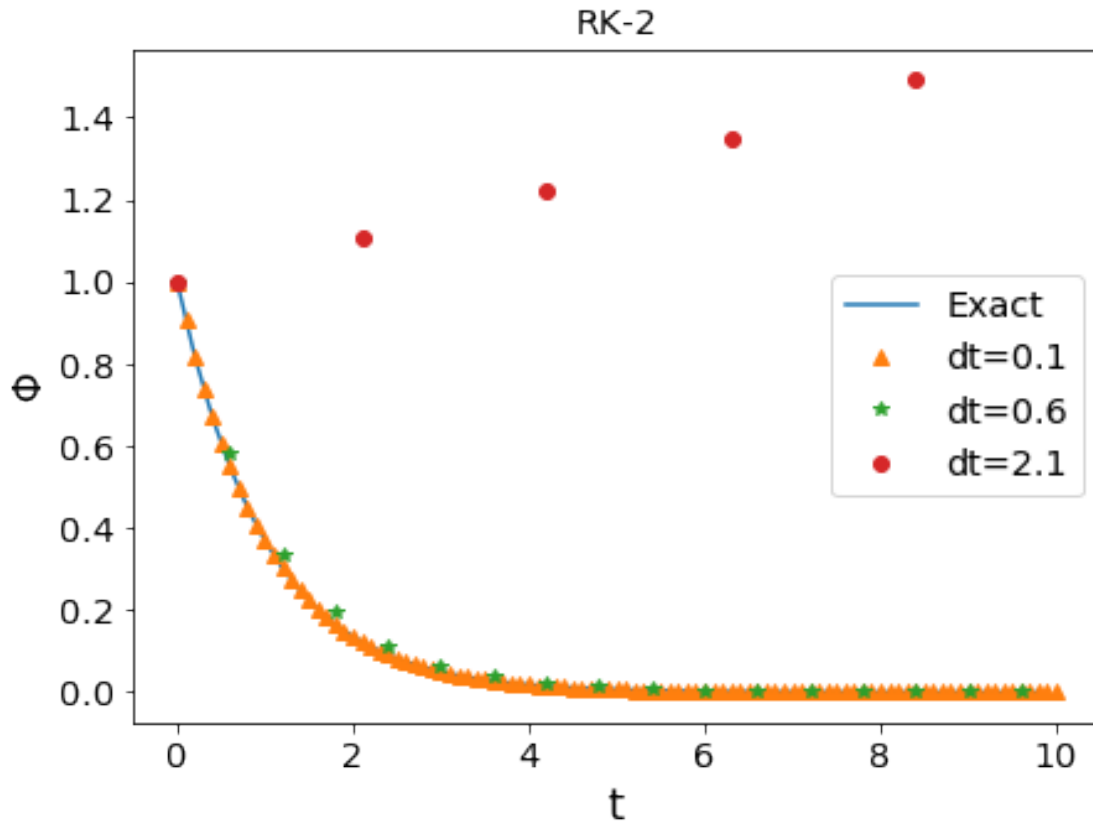
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel(' ', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0,1,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('RK-2')
plt.gca().legend(('Exact', 'dt=0.1', 'dt=0.6', 'dt=2.1'))
plt.savefig('RK-2.png')
plt.show()

```

1.5 RK-3

```
[86]: import csv

with open('rk3Euq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('rk3Euq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('rk3Euq1_2_1.txt') as inf:
    x3 = []
```

```

y3 = []
for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[87]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

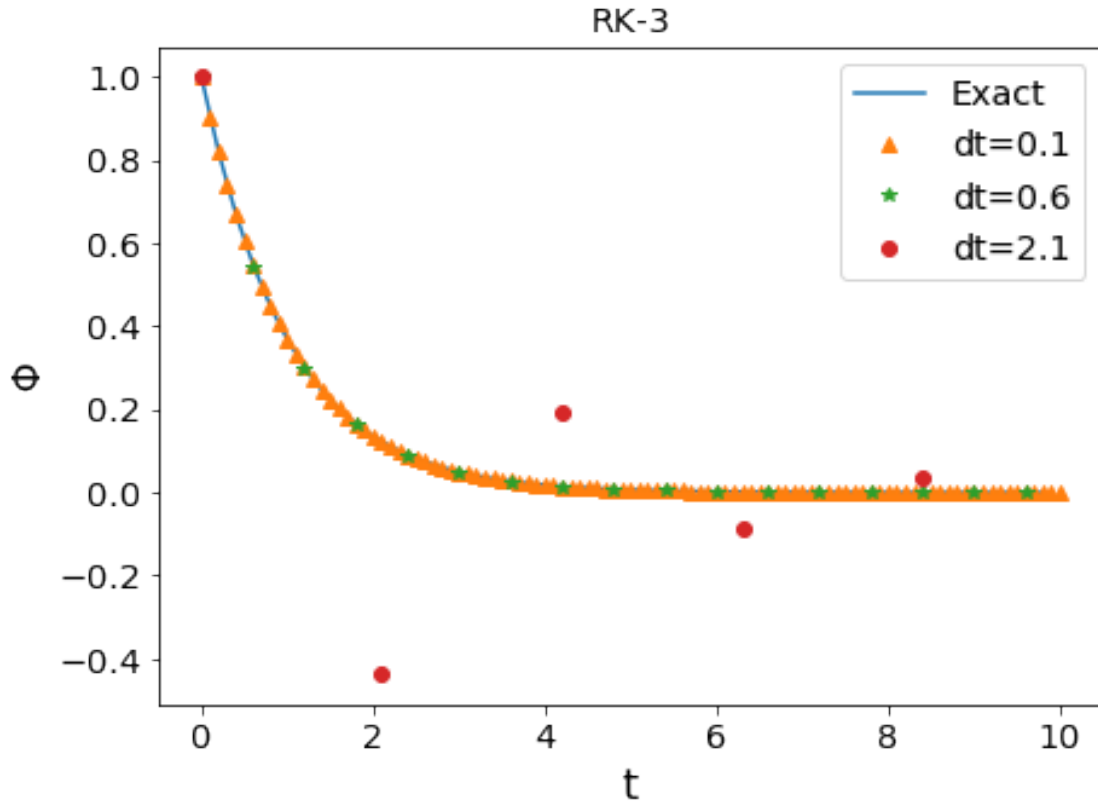
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel(' ', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0,1,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('RK-3')
plt.gca().legend(('Exact', 'dt=0.1', 'dt=0.6', 'dt=2.1'))
plt.savefig('RK-3.png')
plt.show()

```



1.6 RK-3(Williamson)

```
[88]: import csv

with open('rk3WilliamsonEuq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('rk3WilliamsonEuq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('rk3WilliamsonEuq1_2_1.txt') as inf:
    x3 = []
```

```

y3 = []
for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[89]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

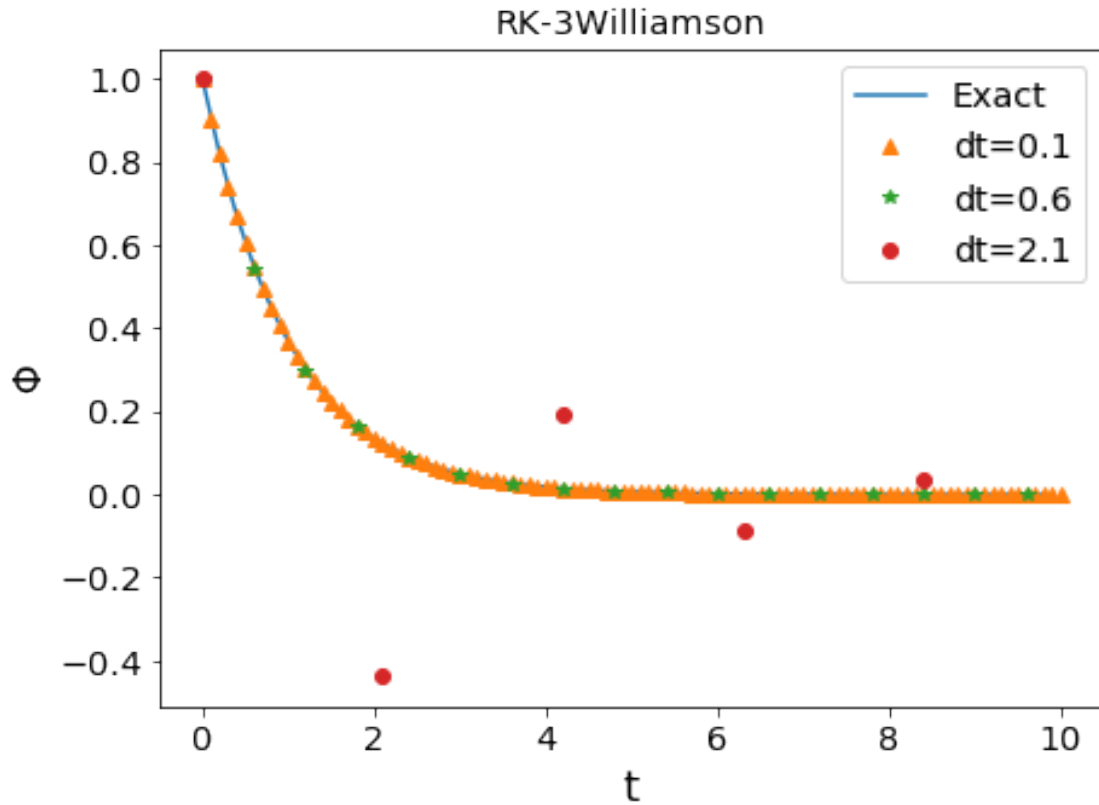
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel(' ', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0,1,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('RK-3Williamson')
plt.gca().legend(('Exact','dt=0.1','dt=0.6','dt=2.1'))
plt.savefig('RK-3Williamson.png')
plt.show()

```



1.7 RK-4

```
[90]: import csv

with open('rk4Euq1_0_1.txt') as inf:
    x1 = []
    y1 = []
    for line in csv.reader(inf):
        tx, ty = line
        x1.append(float(tx))
        y1.append(float(ty))
with open('rk4Euq1_0_6.txt') as inf:
    x2 = []
    y2 = []
    for line in csv.reader(inf):
        tx, ty = line
        x2.append(float(tx))
        y2.append(float(ty))
with open('rk4Euq1_2_1.txt') as inf:
    x3 = []
    y3 = []
```

```

for line in csv.reader(inf):
    tx, ty = line
    x3.append(float(tx))
    y3.append(float(ty))

```

```

[91]: import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pyplot as pylab
params = {'legend.fontsize': 'x-large',
          'figure.figsize': (7,5),
          'axes.labelsize': 'x-large',
          'axes.titlesize': 'x-large',
          'xtick.labelsize': 'x-large',
          'ytick.labelsize': 'x-large'}
pylab.rcParams.update(params)

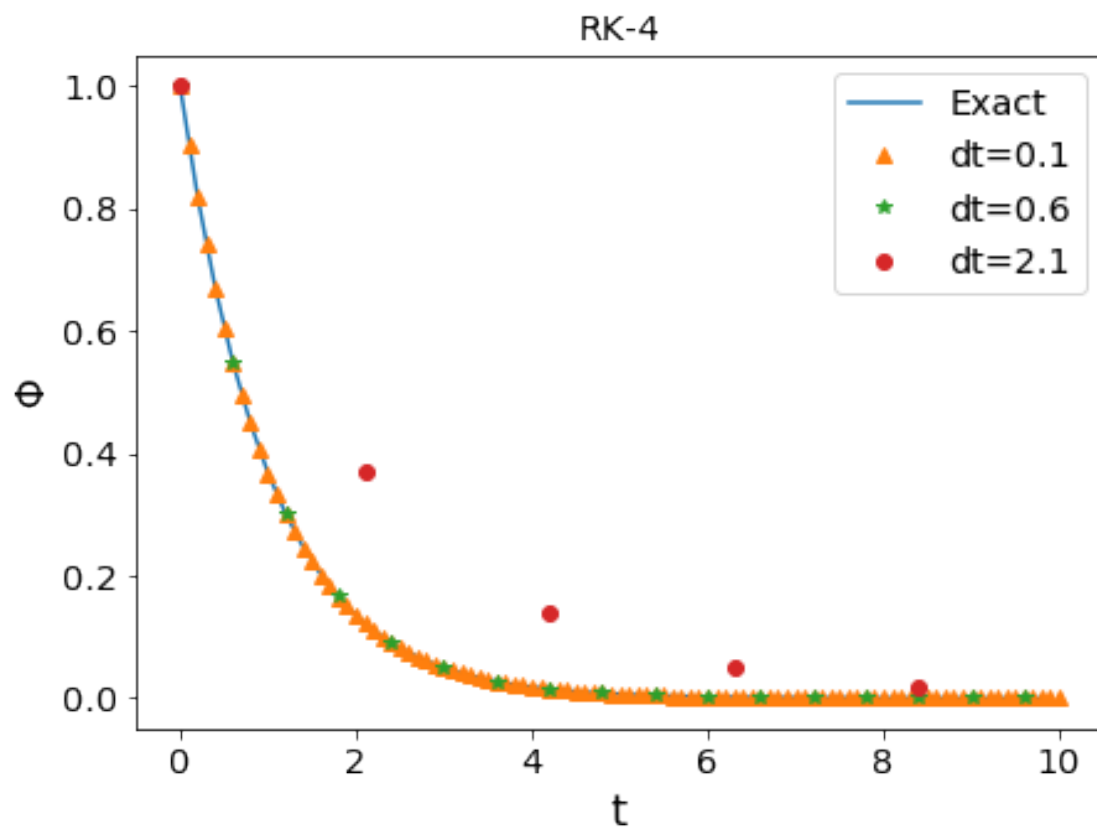
# Create the vectors X and Y
tx = np.arange(0, 10, 0.2)
ty = np.exp(-tx)

plt.xlabel('t', fontsize=18)
plt.ylabel('y', fontsize=16)

# Create the plot
plt.plot(tx,ty,'-', label='Exact')
plt.plot(x1,y1,'^', label='dt=0.1')
plt.plot(x2,y2,'*', label='dt=0.6')
plt.plot(x3,y3,'o', label='dt=2.1')
#x1 = np.arange(0 ,1 ,0.1)
#y1 = 1+3*x

#lt.plot(x1,y1,'^', label='n=1')
# Show the plot
#plt.legend()
plt.title('RK-4')
plt.gca().legend(('Exact', 'dt=0.1', 'dt=0.6', 'dt=2.1'))
plt.savefig('RK-4.png')
plt.show()

```



[]: