04.23

finiteDiff.py

```
'''
Find the first and second derivatives at x = 0, 0.2, and 0.4 of the
following dataset
x    = 0       0.1    0.2    0.3     0.4
f(x) = 0.0000   0.0819  0.1341  0.1646   0.1797
'''

x = [0,0.1,0.2,0.3,0.4]
f = [0.0,0.0819,0.1341,0.1646,0.1797]

 # Finite difference in the abscissa h
 h = x[1]-x[0]

 nc = 2
 # Forward difference calculation
 f1f = (f[nc+1] - f[nc]) / h
 f2f = (f[nc] - 2*f[nc+1] + f[nc+2]) / h**2

 # Central difference calculation
 f1c = (f[nc+1] - f[nc-1]) / (2*h)
 f2c = (f[nc+1] - 2*f[nc] + f[nc-1]) / h**2

 # Backward difference calculation
 f1b = (-f[nc-1] + f[nc]) / h
 f2b = (f[nc-2] - 2*f[nc-1] + f[nc]) / h**2

 r = lambda x:round(x,8)

 print("Forward vs Central vs Backward f1 at x = 0.2
",r(f1f),r(f1c),r(f1b))
 print("Forward vs Central vs Backward f2 at x = 0.2
",r(f2f),r(f2c),r(f2b))

 # Forward difference at x = 0
 nc = 0
 f1f = (f[nc+1] - f[nc]) / h
 f2f = (f[nc] - 2*f[nc+1] + f[nc+2]) / h**2

 print('')
 print('Forward f1 and f2 at x = 0  ',r(f1f),r(f2f))
```

```
 $ python finiteDiff.py
Forward vs Central vs Backward f1 at x = 0.2   0.305 0.4135 0.522
Forward vs Central vs Backward f2 at x = 0.2   -1.54 -2.17 -2.97


Forward f1 and f2 at x = 0   0.819 -2.97
```

richardson.py

```
1. ## f(x) = exp(-x), find f''(x = 1)
2. ## solution = 0.36787944117144233
3. ## Consider h from 1 to 0.001
4.
5. import numpy as np
6.
7. mapli = lambda f,x:list(map(f,x))
8. h = [1,10,50,100,500,1000]
9.
10.  h = mapli(lambda x:1/x,h)
11.
12.  for i in h:
13.      x = -1
14.      npr = 12
15.      f1 = (round(np.exp(x + i),npr) - round(np.exp(x - i),npr)) /
    (2*i)
16.      print('Derivatives, h ',f1, i)
```

```
 $ python richardson.py
Derivatives, h  0.43233235838149997 1.0
Derivatives, h  0.36849288021500004 0.1
Derivatives, h  0.3679039669500006 0.02
Derivatives, h  0.3678855725000013 0.01
Derivatives, h  0.3678796862500028 0.002
Derivatives, h  0.36787950250000145 0.001
```

h 가 줄어들수록 Derivatives 값이 수렴하는 것으로 보인다.

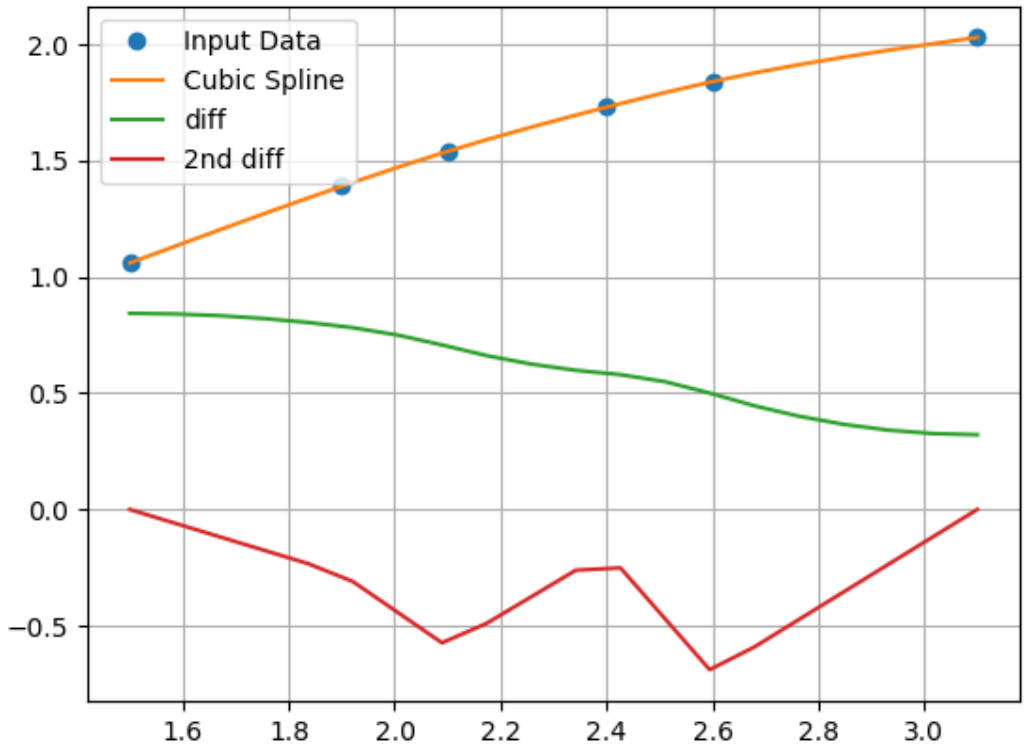
04.30

interpolation.py

```
1. import numpy as np
2. import matplotlib.pyplot as plt
3.
4. x = np.array([1.5,1.9,2.1,2.4,2.6,3.1])
5. y = np.array([1.06,1.39,1.54,1.73,1.84,2.03])
6.
7. xar = np.linspace(1.5,3.1,20)
8.
9. import os
10.  import sys
11.  sys.path.append(os.path.dirname(os.path.abspath(os.path.dirname(__f
   ile__))))
12.
13.  from cubicSpline import *
14.
15.  xData = x; yData = y
16.  kvals = curvatures(xData,yData)
17.
18.  def SplineDiff(xData,yData,k,x):
19.      def findSegment(xData,x):
20.          iLeft = 0
21.          iRight = len(xData) - 1
22.          while 1:
23.              if (iRight-iLeft) <= 1:
24.                  return iLeft
25.              i = round((iLeft + iRight)/2)
26.  #            print('i ',i, 'x ',x,' xData[i]', xData[i])
27.              if x < xData[i] :
28.                  iRight = i
29.              else:
30.                  iLeft = i
31.
32.      i = findSegment(xData,x)
33.      h = xData[i] - xData[i+1]
34.      y = (3*(x - xData[i+1])**2/h - h)*k[i]/6.0   \
35.          - (3*(x - xData[i])**2/h - h)*k[i+1]/6.0   \
36.          + (yData[i] - yData[i+1])/h
37.      return y
38.
39.  def SplineDiff2(xData,yData,k,x):
40.      def findSegment(xData,x):
41.          iLeft = 0
42.          iRight = len(xData) - 1
43.          while 1:
44.              if (iRight-iLeft) <= 1:
45.                  return iLeft
46.              i = round((iLeft + iRight)/2)
47.  #            print('i ',i, 'x ',x,' xData[i]', xData[i])
48.              if x < xData[i] :
49.                  iRight = i
50.              else:
51.                  iLeft = i
52.
53.      i = findSegment(xData,x)
```

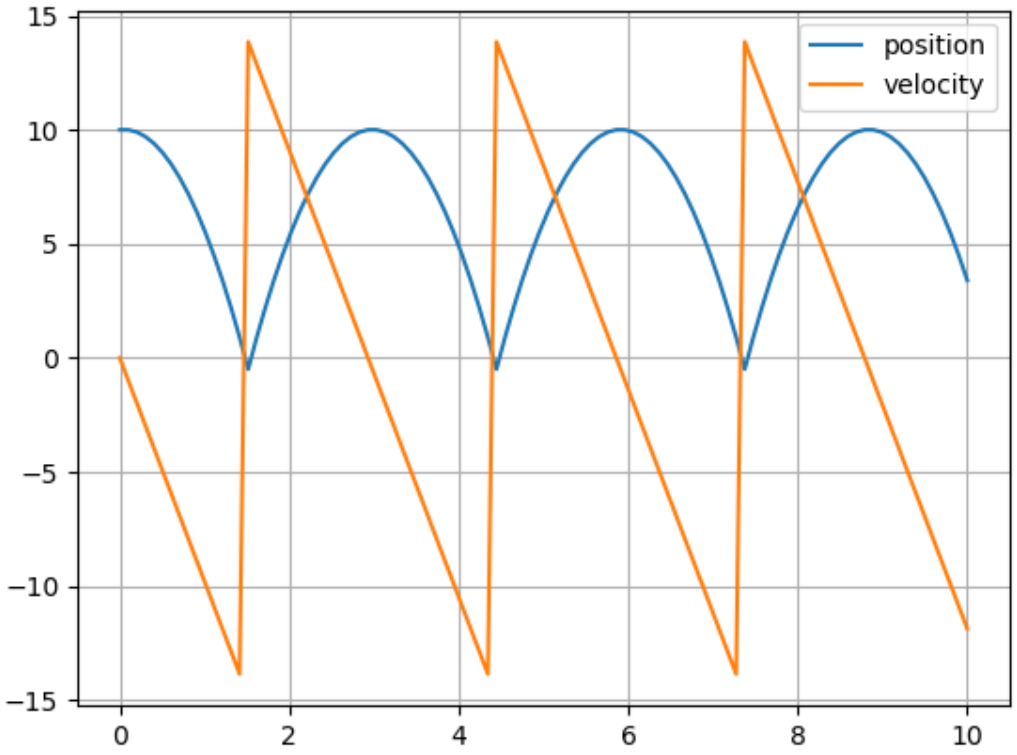
```
54.      h = xData[i] - xData[i+1]
55.      y = (x - xData[i+1])/h*k[i] - (x - xData[i])/h*k[i+1]
56.      return y
57.
58.  yar = []; dy = []; d2y = []
59.  for i in range(len(xar)):
60.      ydata = evalSpline(xData,yData,kvals,xar[i])
61.      dydata = SplineDiff(xData,yData,kvals,xar[i])
62.      d2ydata = SplineDiff2(xData,yData,kvals,xar[i])
63.      yar.append(ydata)
64.      dy.append(dydata)
65.      d2y.append(d2ydata)
66.
67.  plt.plot(xData,yData,'o',xar,yar,'-',xar,dy,'-',xar,d2y,'-')
68.  plt.legend(['Input Data','Cubic Spline','diff','2nd diff'])
69.  plt.grid()
70.  plt.show()
71.
72.  from polyFit import *
73.  m = 2
74.  coeffs = polyFit(kvals,yData,m)
75.  print( 'Coefficients ', coeffs)
```

```
$ python interpolation.py
Coefficients  [1.58253871 0.62313381 1.24690869]
```



freeFallMotion.py

```
1. import numpy as np
2. import matplotlib.pyplot as plt
3.
4. # We wnt to find the height versus time
5.
6. time = np.linspace(0,10,100)
7. y0  = 10       # Ten meters high
8. a   = -9.8     # Meters/sec^2
9. v0  = 0
10.
11.
12.  var = [0.0]
13.  yar = [10.0]
14.  for i in range(len(time)-1) :
15.
16.      dt = time[i+1] - time[i]
17.      var.append( var[i] + a*dt )
18.      yar.append( yar[i] + var[i]*dt )
19.
20.      if yar[i+1] < 0 : var[i+1] = -var[i]
21.
22.  plt.plot(time,yar,'-',time,var,'-')
23.  plt.legend(['position','veloity'])
24.  plt.grid()
25.  plt.show()
```



I want to show moving visualized object so made physics engine using c++.

This is that program’s url.

https://github.com/ingBE/comphy/blob/master/HW7/freefallMotion.exe

and maby you need this .dll files.

https://github.com/ingBE/comphy/blob/master/HW7/bin/

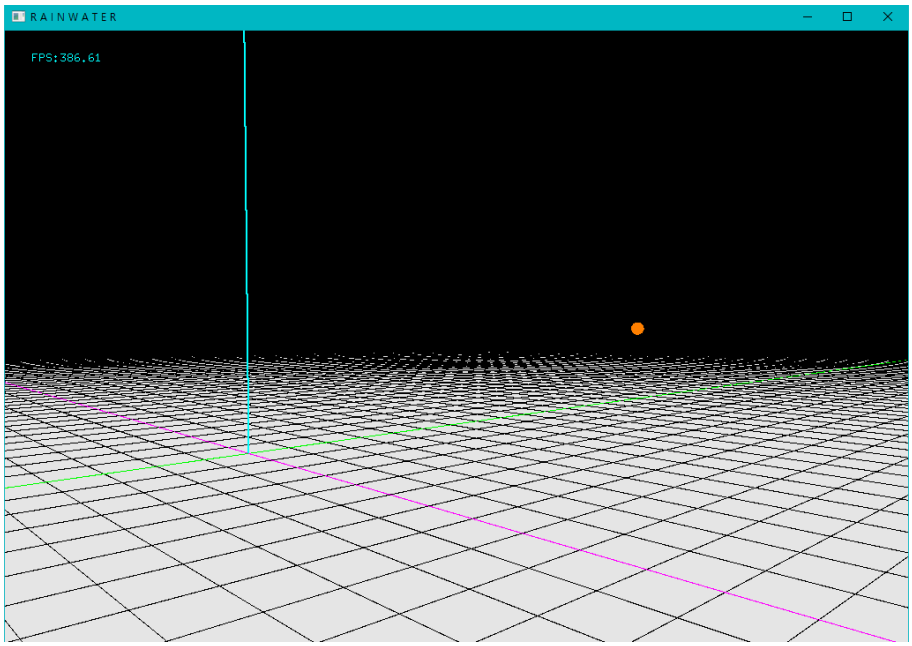
This is codes of physics engine and freeFallMotion program.

https://github.com/ingBE/RWengine/blob/master/demos/freefallMotion.cpp

Move in program to press w, a, s, d, space, c.

Control viewpoint to drag mouse.

Press enter button for initializing position and velocity of object.

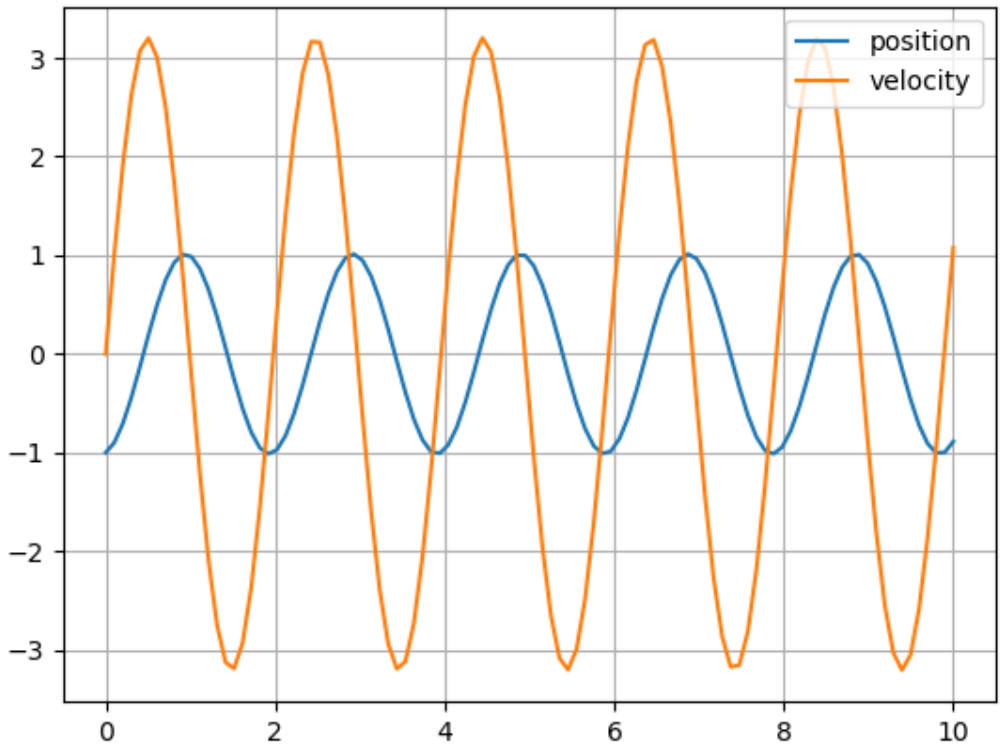


2. a)

HW7_2a.py

```
1. import numpy as np
2.
3. time = np.linspace(0,10,100)
4. x = [-1.0]  # x0 = -1.0 meter
5. v = [ 0.0]  # v0 = 0 meter/sec
6. m = 0.5 # kg
7. k = 5   # N/m
8.
9. for i in range(len(time)-1):
10.
11.     dt = time[i+1] - time[i]
12.     a = - k/m * x[i]    # calculate the accelerate
13.     v.append( v[i] + a*dt ) # calculate the velocity
14.     x.append( x[i] + v[i+1]*dt )  # calculate the new position
15.
16.  import matplotlib.pyplot as plt
17.  plt.plot(time,x,'-',time,v,'-')
18.  plt.legend(['position','velocity'])
19.  plt.grid()
20.  plt.savefig('HW7_2a')
```

HW7_2a.png

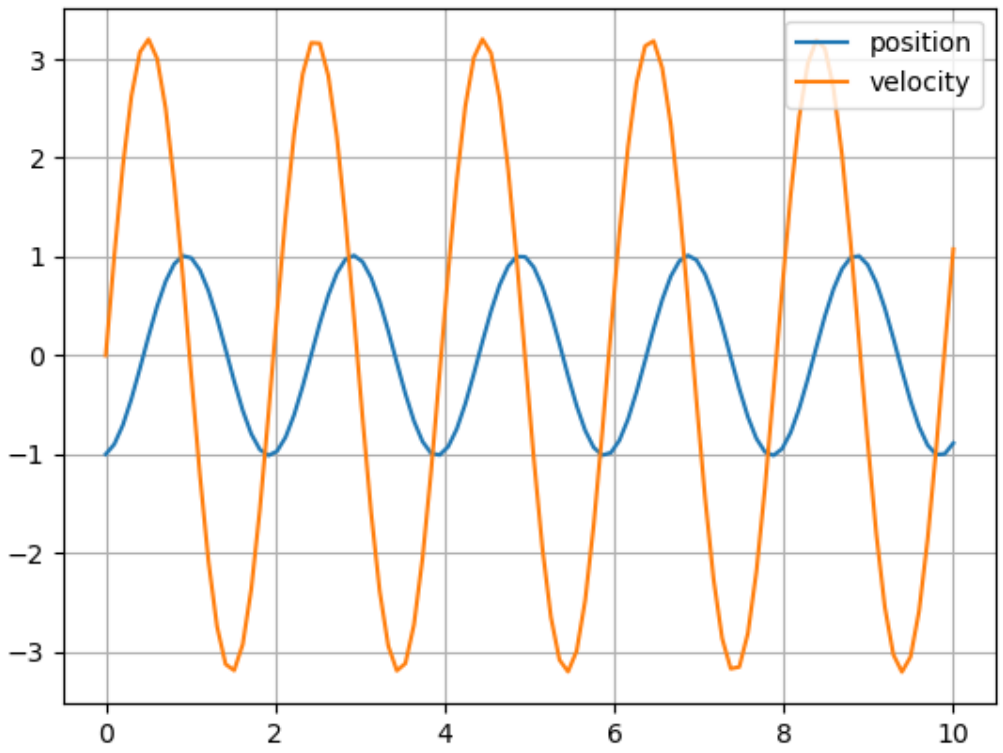


Position graph is same with solution of newton's equation $x(t) = \cos(\sqrt{\frac{k}{m}}t + \phi)$.

2. b)

```
1. import numpy as np
2.
3. time = np.linspace(0,10,100)
4. x = [-1.0]  # x0 = -1.0 meter
5. v = [ 0.0]  # v0 = 0 meter/sec
6. m = 0.5 # kg
7. k = 5   # N/m
8.
9. # calculate to use leapfrog method
10.  for i in range(len(time)-1):
11.
12.      dt = time[i+1] - time[i]
13.      a  = - k/m * x[i]    # calculate the accelerate
14.      v_ = v[i] + a*dt/2   # calculate v[i+1/2]
15.      v.append( v_ + a*dt/2 ) # calculate the velocity
16.      x.append( x[i] + v[i+1]*dt )  # calculate the new position
17.
18.  import matplotlib.pyplot as plt
19.  plt.plot(time,x,'-',time,v,'-')
20.  plt.legend(['position','velocity'])
21.  plt.grid()
22.  plt.savefig('HW7_2b')
```

HW7_2b.png



It is almost same with HW7_2a.png.