

Scientific Computing in Python

1. Numerical Integration : scipy.integrate

When integrating a function analytically is not possible or is extremely difficult to integrate, numerical integration methods can be used.

SciPy provides functions to perform integrations from ordinary differential equations to trapezoidal rules.

Numerical Integration is also sometimes called Quadrature. It performs single integration of a function $f(x)$ in the range which is fixed from a to b . In scipy it is the quad function. If the integration is double, triple or more, the functions used are dblquad, tplquad and nquad respectively.

Ordinary Differential equations can also be integrated using `scipy.integrate.odeint`.

Example 1: Single Integration

```
import scipy.integrate
from numpy import exp
f = lambda x: exp(-x**3)
#f is the function to be integrated, 0 is the lower limit and 1 is the upper limit
print(scipy.integrate.quad(f, 0, 1))
```

Output: (0.8075111821396714, 8.965175070537417e-15)

Example 2: Double Integration

```
import scipy.integrate
from numpy import exp
from math import sqrt
f = lambda x, y: 16*x*y
g = lambda x: 0
h = lambda y: sqrt(1-4*y**2)
print(scipy.integrate.dblquad(f, 0, 0.5, g, h))
```

Output: (0.5, 1.7092350012594845e-14)

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Example 3: Integrating a Bessel Function

```
import scipy.integrate as integrate
import scipy.special as special
result = integrate.quad(lambda x: special.jv(3.5,x), 0, 5.5)
result
```

Example 4: Integrating a Ordinary Differential Equation

Solving the ODE : $dy/dt = -2y$ between $t = 0 \dots 4$, with the initial condition $y(t=0) = 1$

```
def calc_derivative(ypos, time):
    return -2 * ypos

from scipy.integrate import odeint
import numpy as np
time_vec = np.linspace(0, 4, 10)
y = odeint(calc_derivative, y0=1, t=time_vec)
print(y)
```

Output:

```
[[1.00000000e+00]
 [4.11112313e-01]
 [1.69013313e-01]
 [6.94834400e-02]
 [2.85654998e-02]
 [1.17436289e-02]
 [4.82795070e-03]
 [1.98483034e-03]
 [8.15986861e-04]
 [3.35461690e-04]]
```