

# 运行说明

## 代码思路

直接计算  $I = \int_1^5 \sin(x) dx = -\cos|_1^5 = \cos 1 - \cos 5$

分割数  $n = 2^l, l = 1, 2, \dots, 12$ , 步长  $h = \frac{4}{n}$ 。

复化梯形积分：

$$\begin{aligned} T_n(f) &= h \left[ \frac{1}{2} f(a) + \sum_{i=1}^{n-1} f(a + ih) + \frac{1}{2} f(b) \right] \\ &= h \left[ \frac{1}{2} \sin(1) + \sum_{i=1}^{2^l-1} \sin(1 + ih) + \frac{1}{2} \sin(5) \right] \end{aligned}$$

$$E_n = I - T_n$$

复化Simpson积分：

$$\begin{aligned} S_n(f) &= \frac{h}{3} [f(a) + 4 \sum_{i=0}^{n/2-1} f(a + (2i+1)h) + 2 \sum_{i=1}^{n/2-1} f(a + 2ih) + f(b)] \\ &= \frac{h}{3} [\sin(1) + 4 \sum_{i=1}^{2^{l-1}-1} \sin(1 + (2i+1)h) + 2 \sum_{i=1}^{2^{l-1}-1} \sin(1 + 2ih) + \sin 5] \end{aligned}$$

$$E_n = I - S_n$$

取  $k = 2$ , 使用  $l$ , 和  $l - 1$  误差计算误差阶。

## 实现细节

使用两个函数分别计算复化梯形积分和复化Simpson积分和误差,被积函数sin作为函数指针传入,并传入积分上下限。将积分方式以函数指针的方式传入另一个函数计算误差和误差阶并输出结果。main函数输入函数类型并调用以上函数输出结果。具体细节见注释。

## 运行结果

```
Enter full name of type of integral:
trapezoid
Enter lower limit:
1.0
Enter upper limit:
5.0
l = 1 : 积分值 = 1.647867262644925e-01 , 误差 = 9.185339414042104e-02 , 误差阶不存在
l = 2 : 积分值 = 2.348882946499998e-01 , 误差 = 2.175182575491369e-02 , 误差阶 = -2.078196532702638e+00
l = 3 : 积分值 = 2.512710400016470e-01 , 误差 = 5.369080403266502e-03 , 误差阶 = -2.018389584797571e+00
l = 4 : 积分值 = 2.553020586741641e-01 , 误差 = 1.338061730749407e-03 , 误差阶 = -2.004530334299476e+00
l = 5 : 积分值 = 2.563058665264722e-01 , 误差 = 3.342538784413263e-04 , 误差阶 = -2.001128469942099e+00
l = 6 : 积分值 = 2.565565732596342e-01 , 误差 = 8.354714527930573e-05 , 误差阶 = -2.000281861586199e+00
l = 7 : 积分值 = 2.566192346385075e-01 , 误差 = 2.088576640602025e-05 , 误差阶 = -2.000070449349853e+00
l = 8 : 积分值 = 2.566348990270507e-01 , 误差 = 5.221377862851817e-06 , 误差阶 = -2.000017611228321e+00
l = 9 : 积分值 = 2.566388150644316e-01 , 误差 = 1.305340481927431e-06 , 误差阶 = -2.000004402972962e+00
l = 10 : 积分值 = 2.566397940700425e-01 , 误差 = 3.263348710147440e-07 , 误差阶 = -2.000001102869666e+00
l = 11 : 积分值 = 2.566400388212106e-01 , 误差 = 8.158370295996420e-08 , 误差阶 = -2.000000261606502e+00
l = 12 : 积分值 = 2.566401000089883e-01 , 误差 = 2.039592522651290e-08 , 误差阶 = -2.000000036320607e+00
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Enter full name of type of integral:
simpson
Enter lower limit:
1.0
Enter upper limit:
5.0
1 = 1 : 积分值 = 2.980178282561513e-01 , 误差 = -4.137770785123773e-02 , 误差阶不存在
1 = 2 : 积分值 = 2.582554841118356e-01 , 误差 = -1.615363706922057e-03 , 误差阶 = -4.678922791905744e+00
1 = 3 : 积分值 = 2.567319551188625e-01 , 误差 = -9.183471394902387e-05 , 误差阶 = -4.136675618835332e+00
1 = 4 : 积分值 = 2.566457315650030e-01 , 误差 = -5.611160089513678e-06 , 误差阶 = -4.032668622773915e+00
1 = 5 : 积分值 = 2.566404691439080e-01 , 误差 = -3.487389944600849e-07 , 误差阶 = -4.008079480226855e+00
1 = 6 : 积分值 = 2.566401421706883e-01 , 误差 = -2.176577473811392e-08 , 误差阶 = -4.002014411034314e+00
1 = 7 : 积分值 = 2.566401217647997e-01 , 误差 = -1.359886203644578e-09 , 误差阶 = -4.000503537024864e+00
1 = 8 : 积分值 = 2.566401204898975e-01 , 误差 = -8.498401982137693e-11 , 误差阶 = -4.000150534384884e+00
1 = 9 : 积分值 = 2.566401204102254e-01 , 误差 = -5.311917572470293e-12 , 误差阶 = -3.999886921059888e+00
1 = 10 : 积分值 = 2.566401204052468e-01 , 误差 = -3.332334408412407e-13 , 误差阶 = -3.994627668604060e+00
1 = 11 : 积分值 = 2.566401204049301e-01 , 误差 = -1.659783421814609e-14 , 误差阶 = -4.327466278428792e+00
1 = 12 : 积分值 = 2.566401204049176e-01 , 误差 = -4.107825191113079e-15 , 误差阶 = -2.014548308569155e+00
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