

تکلیف سری اول درس دینامیک سیالات محاسباتی پیشرفته محمد یوسفی 402126084  
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```
import numpy as np
import matplotlib.pyplot as plt
from scipy.sparse import diags
from scipy.sparse.linalg import gcrotmk

def S(x):
    return 1000 * x * (1 - x) # definition of source term

K2, K3, H = [], [], []
i = 1
N = 4 # Starting value for N
increment = 3 # Initial increment
```

الگوریتم انتخاب نقاط به نحوی طراحی شده که نقاط ثابت برای مقایسه خطا با کاهش گام طولی وجود داشته باشد.

```
while N <= 1000:
    L = 1 # length of the bar
    h = L / (N - 1) # step size
    x = np.linspace(0, L, N)
    Phi_left = 300
    Phi_right = 300

    diagonals = [-2 * np.ones(N), 1*np.ones(N-1), 1*np.ones(N-1)]
    A = diags(diagonals, [0, -1, 1], format='csr')
    A[0, 0] = 1
    A[0, 1] = 0
    A[N-1, N-2] = 0
    A[N-1, N-1] = 1

    b = -S(x) * h**2
    b[0] = Phi_left
    b[-1] = Phi_right

    initial_guess = np.zeros(N)

    Phi, info = gcrotmk(A, b, x0=initial_guess)

    Phi[0] = Phi_left
    Phi[-1] = Phi_right
    print(f"N={N}, Solution={Phi}, CG Info={info}")

    K2.append(Phi[1*i]) # values of Phi in x = L/4
    K3.append(Phi[2*i]) # Values of Phi in x = 3L/4
    H.append(h) # storing values of h into H for log-log plot
```

```
N += increment
increment *= 2
i *= 2
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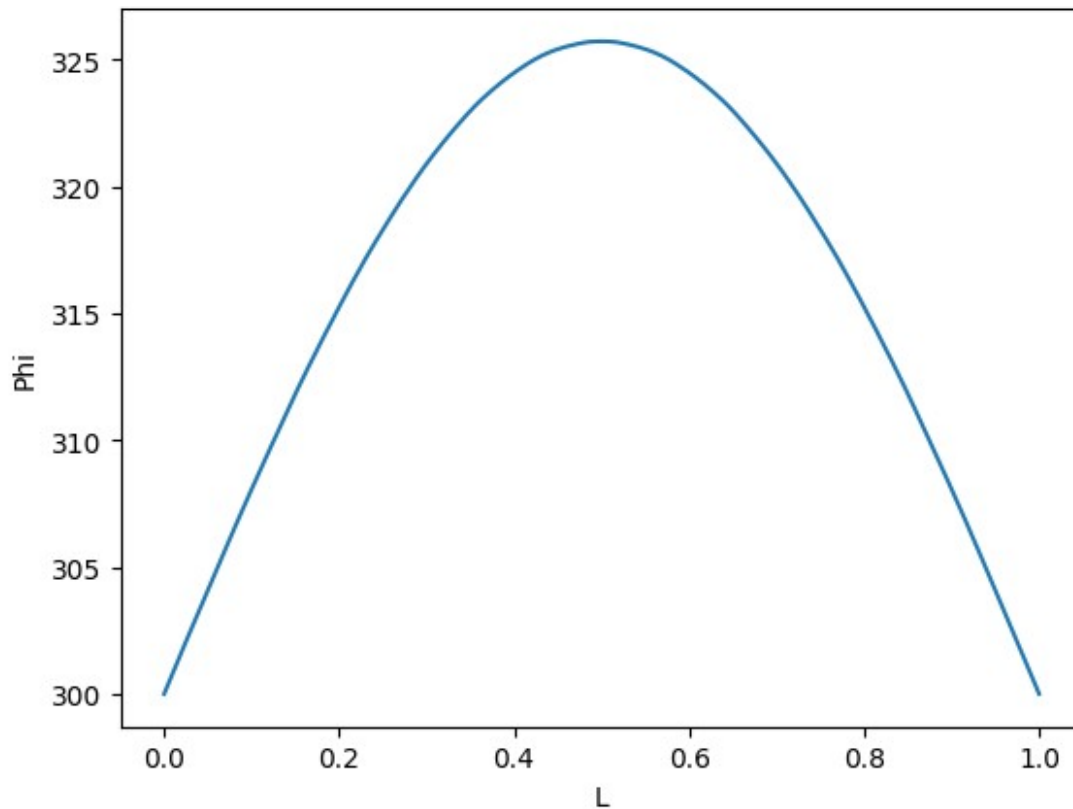
```

```

fig, ax = plt.subplots()
ax.plot(x, Phi)
plt.xlabel('L')
plt.ylabel('Phi')
plt.show()

```





```

dif1 = []
dif2 = []
error = []
j = 0
for i in range(1, len(H)):
    dif1.append(abs(K2[i] - K2[i-1]))
    dif2.append(abs(K3[i] - K3[i-1]))
    error.append(np.linalg.norm([dif1[j], dif2[j]])) # compute norm
of errors at K2 and K3 points in each step-size
    j += 1
del H[0]

plt.loglog(H, error, 'o-', label='Error vs H')

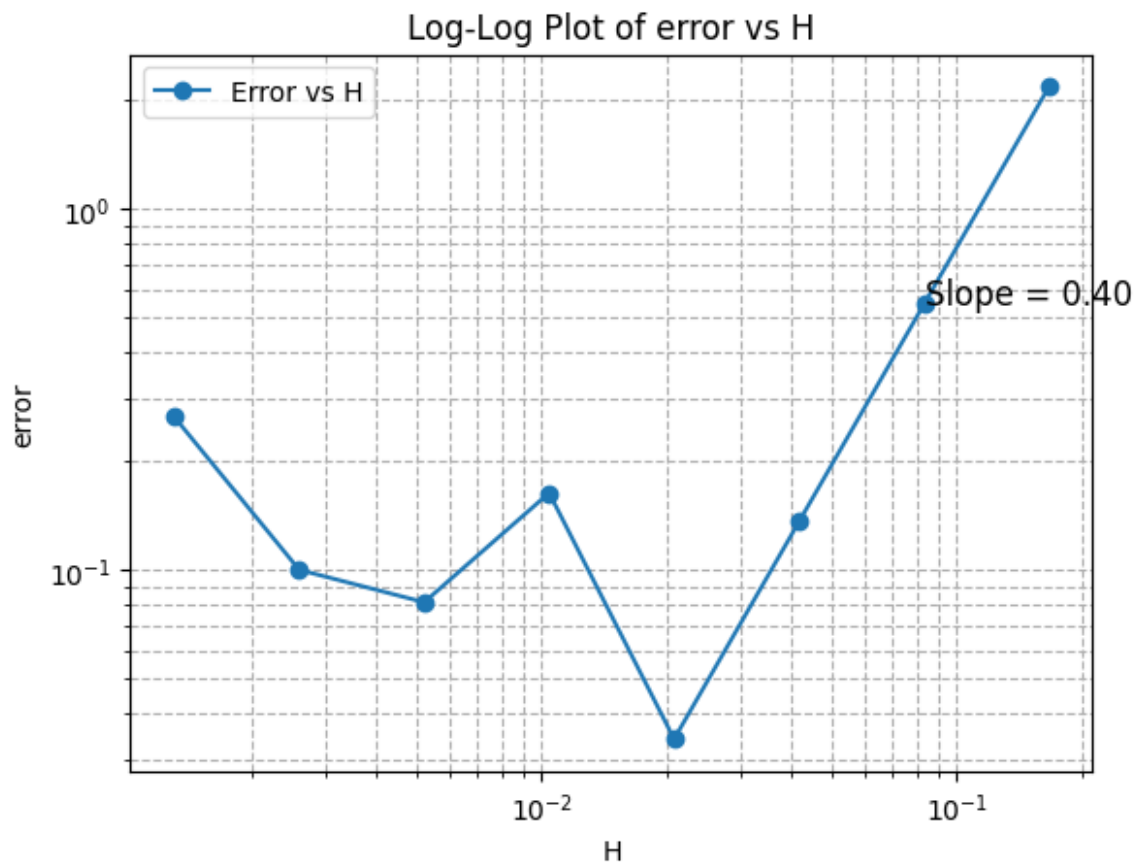
plt.xlabel('H')
plt.ylabel('error')
plt.title('Log-Log Plot of error vs H')
plt.legend()
plt.grid(True, which="both", ls="--")

log_H = np.log(H)
log_error = np.log(error)

slope, intercept = np.polyfit(log_H, log_error, 1)

```

```
plt.text(H[1], error[1], f'Slope = {slope:.2f}', fontsize=12)
plt.show()
```



شکل بالا شیب کلی نمودار خطا در برابر گام طولی را نشان می‌دهد. طبق شکل شیب نمودار تا مقدار خاصی از گام طولی ثابت و نزدیک به 2 است اما پس از آن به دلیل خطاهای احتمالی شیب نامتوازن می‌شود