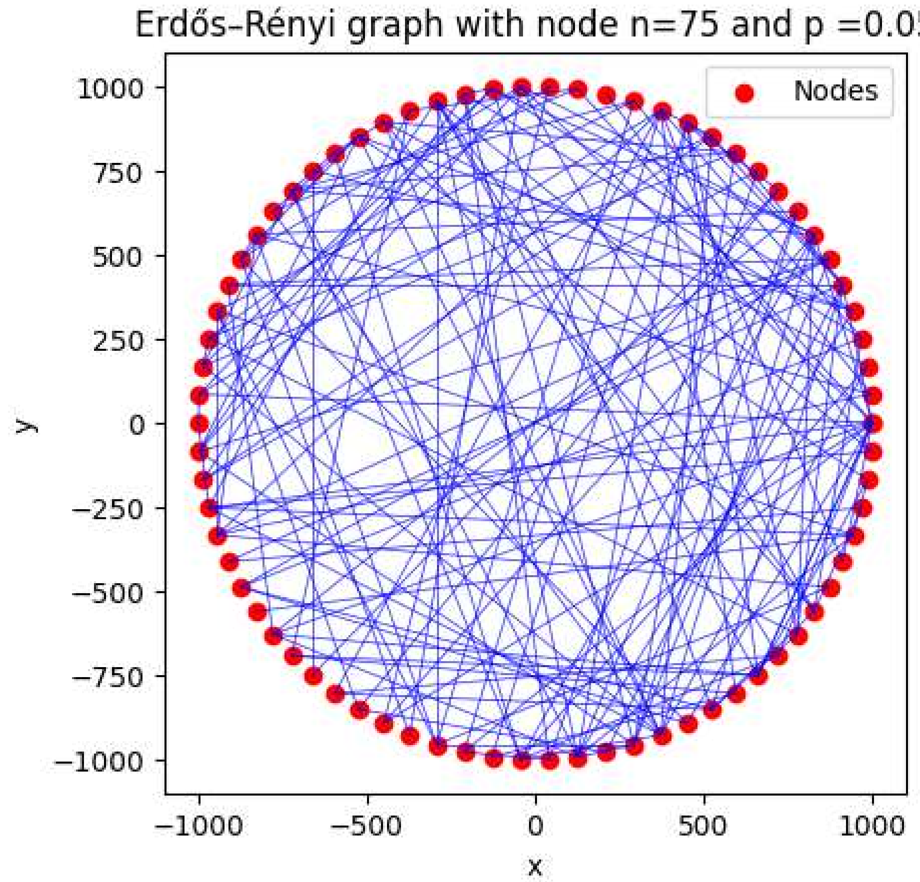
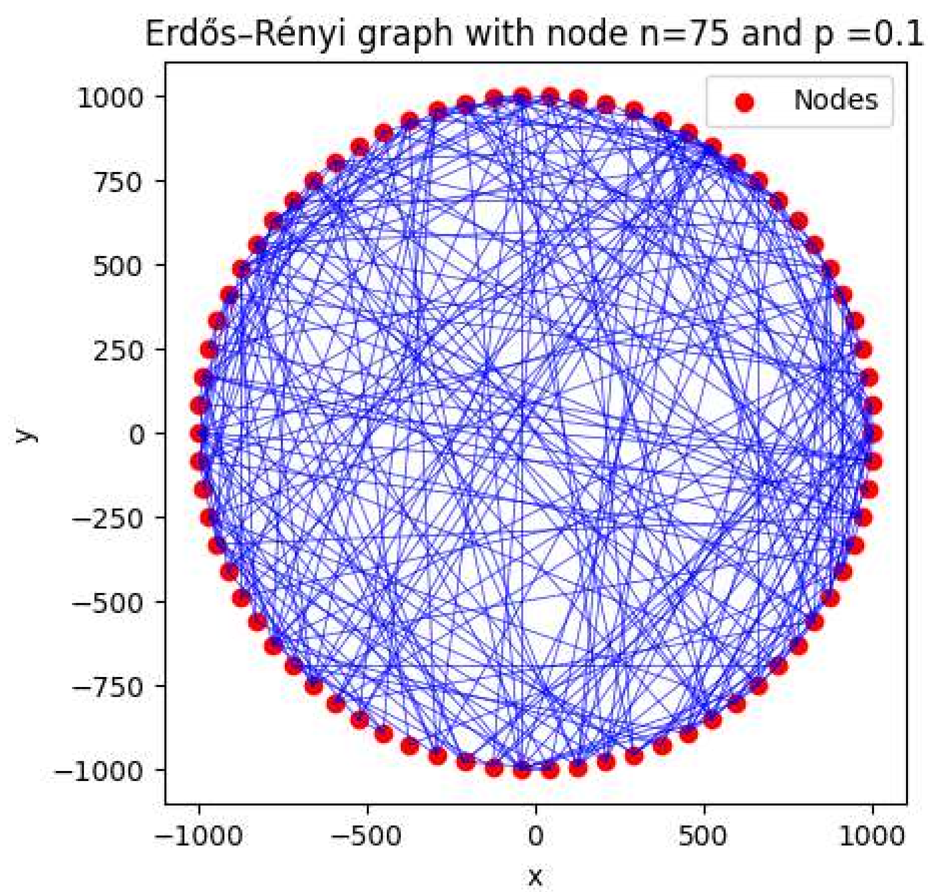
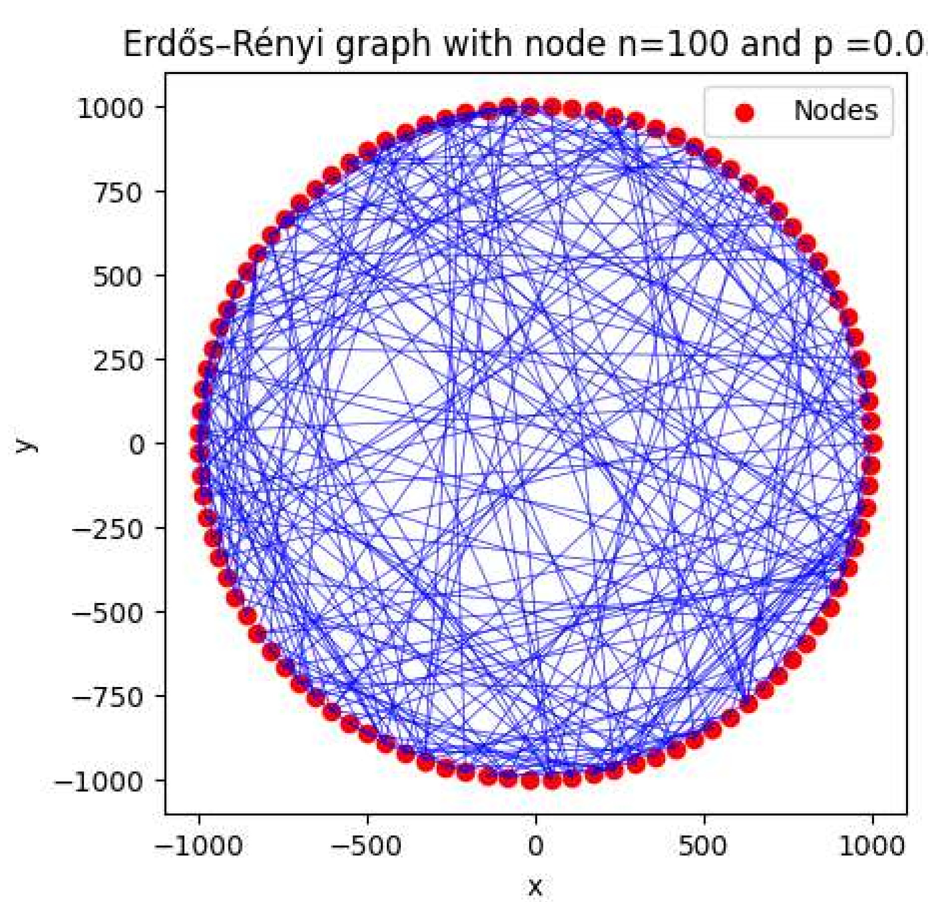
12.1 The Erdős–Rényi random graph

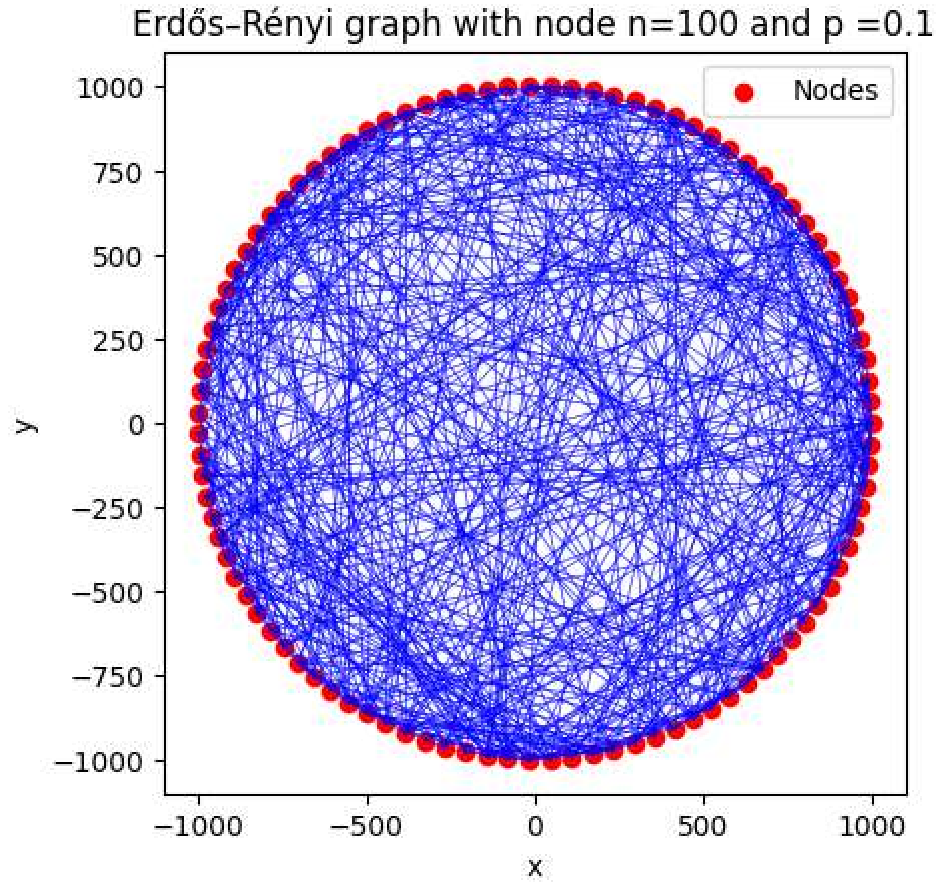
12.1.a

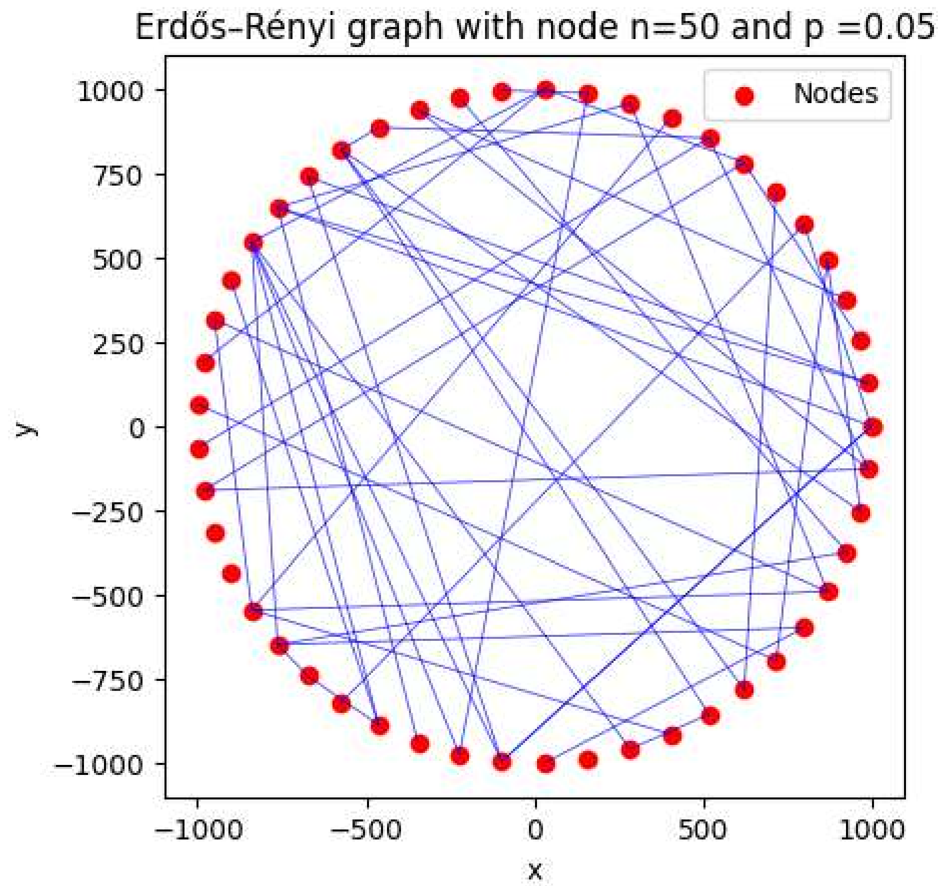
In [ ]:
```
import numpy as np
from matplotlib import pyplot as plt
import random
from scipy.special import comb

n_list= [75,100, 50]
# no_edges = n*(n-1)/2
p_list = [0.05, 0.1]
r = 1000 #radius of circle for plotting
graphnumber =0

for n in n_list:
        for p in p_list:
            graphnumber+=1
            n=n
            p=p
            amatrix = np.zeros((n,n))
            for i in range(n):
                for j in range(n):
                    if i>j:
                        x= random.random()
                        if x< p:
                            amatrix[i][j]= 1
                            amatrix[j][i]=1
            degree= np.zeros((n,1))

            for i in range(n):
                degree[i,:] = np.sum(amatrix[i,:])

            def probability_distribution(n, p, k):
                return comb(n-1, k) * (p**k) * ((1-p)**(n-k-1))

            k_values = np.linspace(0,20,50)
            p_k_list=[]
            for k in k_values:
                p_k_analytical =  probability_distribution(n, p, k)
                p_k_list.append(p_k_analytical)



            theta = np.linspace(0, 2*np.pi, n)
            x = r * np.cos(theta)
            y = r * np.sin(theta)


            # print(amatrix)
            # plt.figure(figsize=(10, 6))

            plt.scatter(x, y, color='red', label='Nodes')
            for i in range(n):
                for j in range(n):
                    if amatrix[i][j] ==1:
                        plt.plot([x[i], x[j]], [y[i], y[j]], color='blue', alpha=0.5, linewidth= 0.5)
            plt.gca().set_aspect('equal', adjustable='box')
            plt.xlabel('x')
            plt.ylabel('y')
            plt.legend()
            plt.title(f'Erdős-Rényi graph with node n={n} and p ={p}')


            plt.show()
```

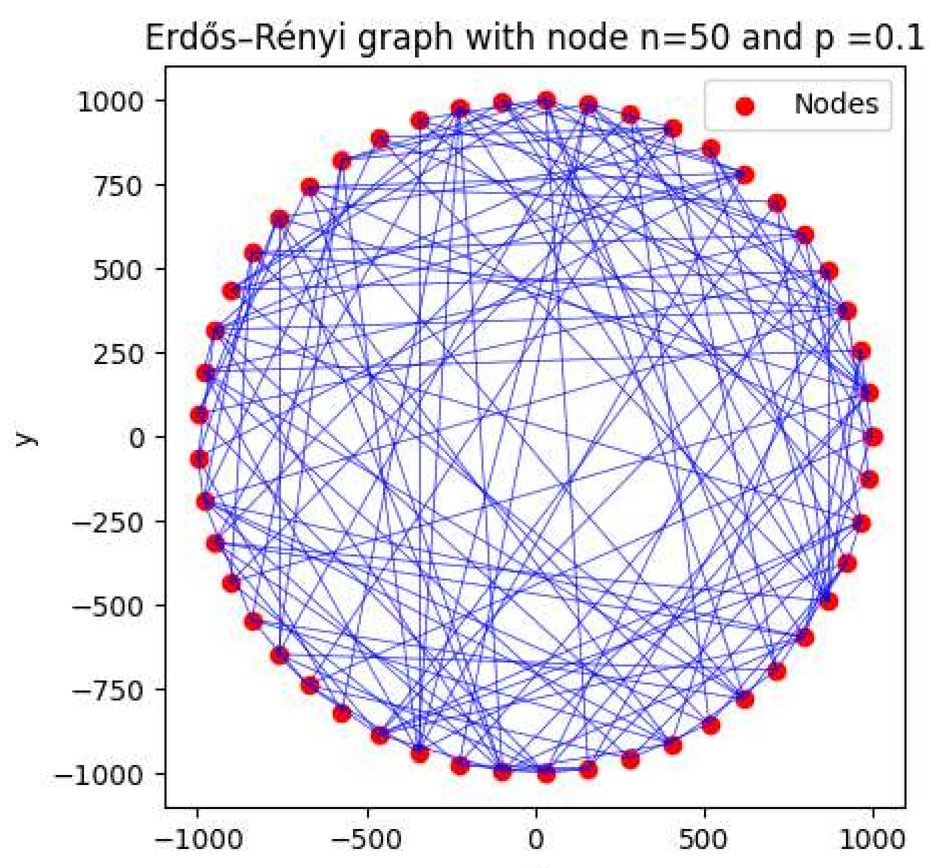

Erdős–Rényi graph with node n=75 and p =0.05
Nodes
y
x


Erdős–Rényi graph with node n=75 and p =0.1
Nodes
y
x


Erdős–Rényi graph with node n=100 and p =0.05
Nodes
y
x



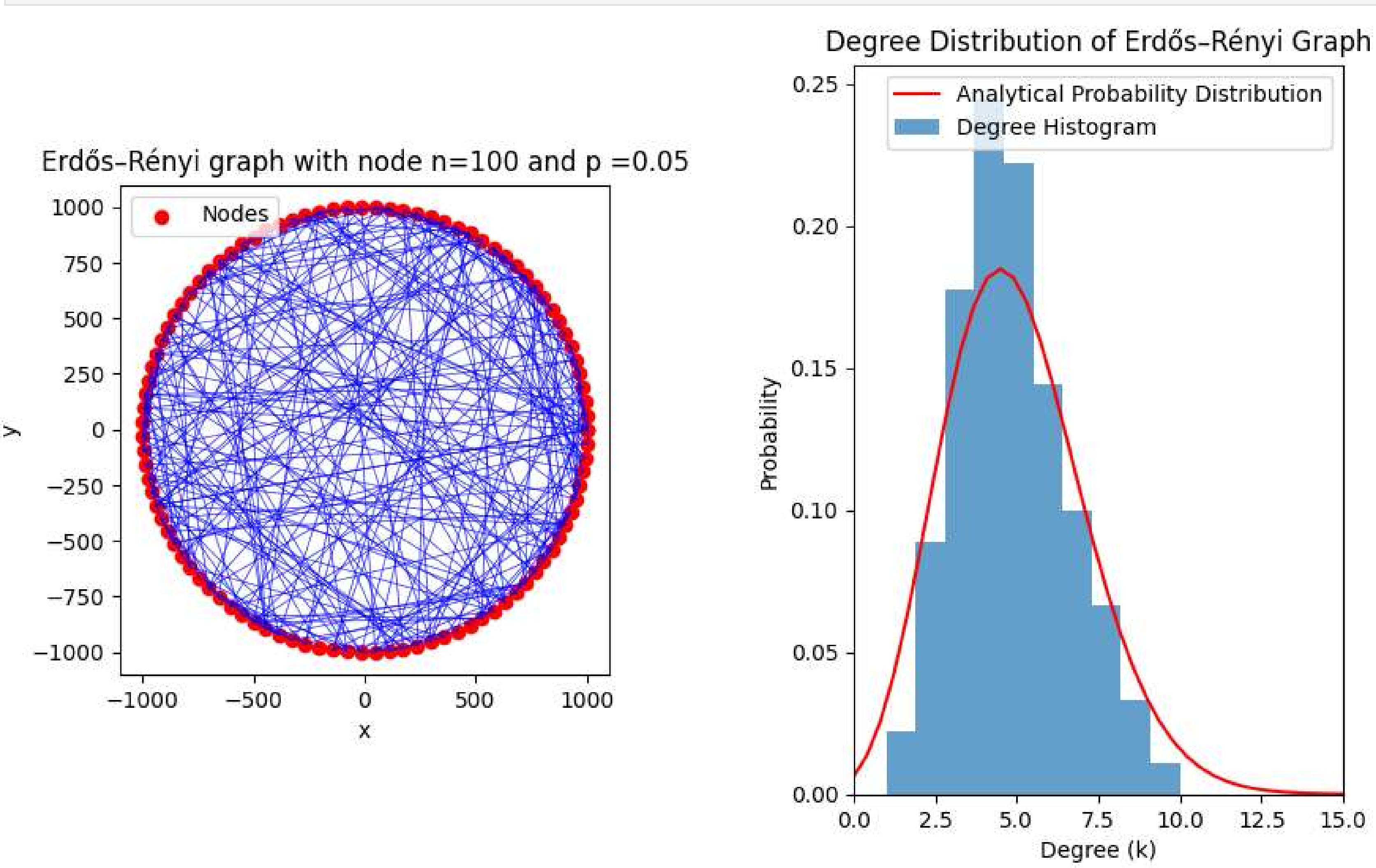




In [ ]:

```
n=100
p=0.05
amatrix = np.zeros((n,n))
for i in range(n):
    for j in range(n):
        if i>j:
            x= random.random()
            if x< p:
```

```
                amatrix[i][j]= 1
                amatrix[j][i]=1
degree= np.zeros((n,1))
for i in range(n):
    degree[i,:] = np.sum(amatrix[i,:])

def probability_distribution(n, p, k):
    return comb(n-1, k) * (p**k) * ((1-p)**(n-k-1))

theta = np.linspace(0, 2*np.pi, n)
x = r * np.cos(theta)
y = r * np.sin(theta)

k_values = np.linspace(0,20,50)
p_k_list=[]
for k in k_values:
    p_k_analytical =  probability_distribution(n, p, k)
    p_k_list.append(p_k_analytical)

# plt.plot(k_values, p_k_list)
# # plt.show()
# plt.hist(degree, bins=12)
# plt.show()



plt.figure(figsize=(10, 6))

plt.subplot(1,2,1)
plt.scatter(x, y, color='red', label='Nodes')
for i in range(n):
    for j in range(n):
        if amatrix[i][j] ==1:
            plt.plot([x[i], x[j]], [y[i], y[j]], color='blue', alpha=0.5, linewidth= 0.5)
plt.gca().set_aspect('equal', adjustable='box')
plt.xlabel('x')
plt.ylabel('y')
plt.legend()
plt.title(f'Erdős-Rényi graph with node n={n} and p ={p}')

plt.subplot(1,2,2)
plt.plot(k_values, p_k_list, label='Analytical Probability Distribution', color='red')
plt.hist(degree, bins=10, density=True, alpha=0.7, label='Degree Histogram')
plt.xlabel('Degree (k)')
plt.ylabel('Probability')
plt.title('Degree Distribution of Erdős-Rényi Graph')
plt.xlim(0,15)
plt.legend()
plt.subplots_adjust(wspace=0.5)

plt.show()
```



In [ ]: