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Lab 12. Analysing real time datasets using networkx package

Exercise 1: Modelling road network of Indian cities

1. Import networkx and matplotlib libraries

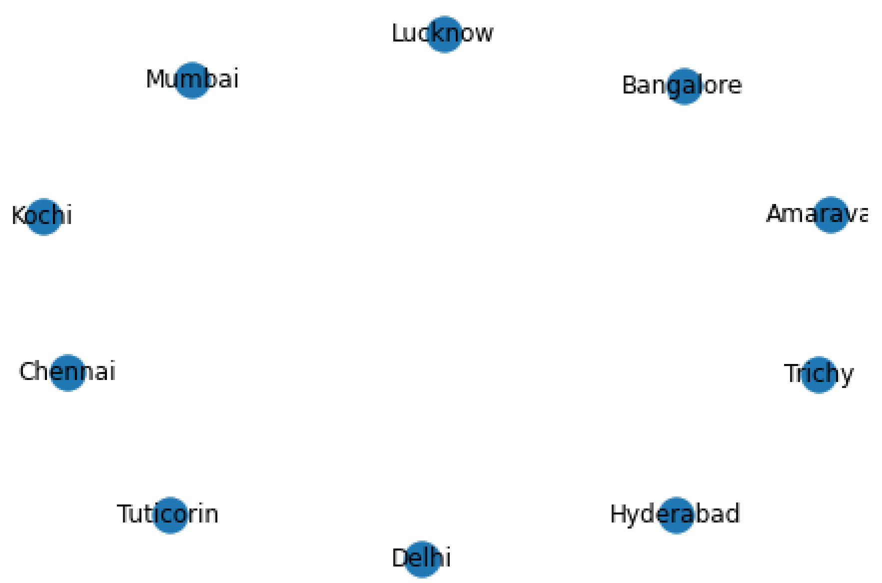
In [2]:

```
import networkx as nx
import matplotlib.pyplot as plt
```

2. Initialise an Undirected Null graph and make a list of cities and make these cities as nodes

In [3]:

```
G = nx.Graph() #Undirected NULL graph
#G = nx.DiGraph() #Directed Graph
cities = ['Delhi', 'Trichy', 'Mumbai', 'Tuticorin', 'Chennai', 'Kochi', 'Hyderabad', 'Banga
for city in cities:
    G.add_node(city)
nx.draw(G, with_labels=1)
plt.show()
```



In [4]:

```
import numpy as np
costs = [np.random.randint(50, 1000) for x in range(10) ]
print (costs)
print (len(costs))
print ("Edges : ", G.number_of_edges())
print ("Nodes : ", G.number_of_nodes())
```

```
[243, 340, 714, 171, 705, 857, 641, 594, 732, 780]
10
Edges :  0
Nodes :  10
```

3. Plot the cities

In [5]:

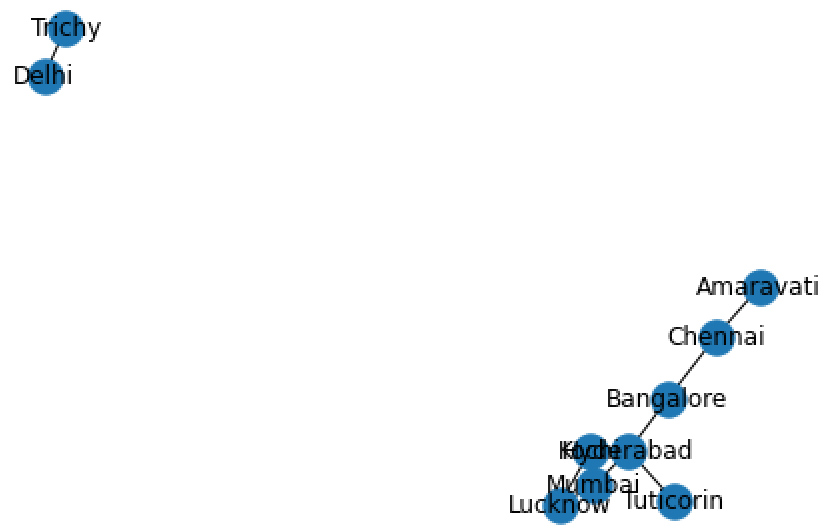
```
from numpy.random import choice
```

In [6]:

```
#Addding 10 edges to the graph
while(G.number_of_edges() != 10):
    city1 = choice(G.nodes())
    city2 = choice(G.nodes())
    wt = choice(costs)#selecting random costs

    if city1 != city2 and G.has_edge(city1, city2) == 0:
        G.add_edge(city1, city2, weight = wt)
print (G.edges())
nx.draw(G, with_labels=1)
plt.show()
```

```
[('Delhi', 'Trichy'), ('Mumbai', 'Lucknow'), ('Mumbai', 'Kochi'), ('Mumbai',
'Hyderabad'), ('Tuticorin', 'Hyderabad'), ('Chennai', 'Amaravati'), ('Chenna
i', 'Bangalore'), ('Kochi', 'Hyderabad'), ('Kochi', 'Lucknow'), ('Hyderaba
d', 'Bangalore')]
```



In [7]:

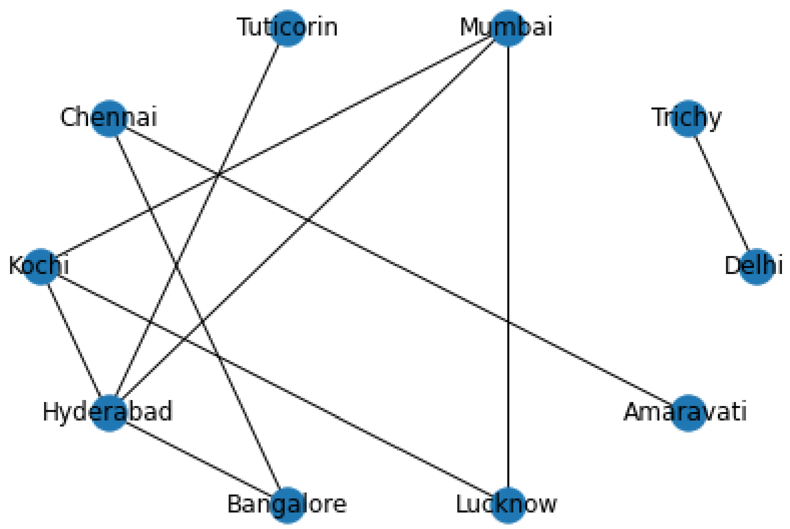
```
pos = nx.spectral_layout(G)
nx.draw(G, pos)
plt.show()
```

In [8]:

```
pos = nx.spring_layout(G)
nx.draw(G, pos)
plt.show()
```

In [9]:

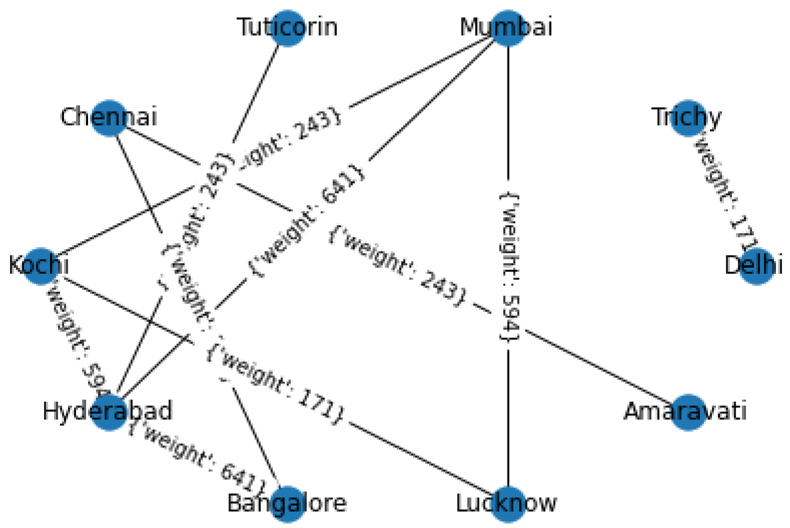
```
pos = nx.circular_layout(G)
nx.draw(G, pos, with_labels=1)
plt.show()
```



4. Create edges among the cities and create weights for the edges

In [10]:

```
#Visulaising edge weights
nx.draw(G, pos, with_labels=1)
nx.draw_networkx_edge_labels(G, pos)
plt.show()
```



In [11]:

```
print (nx.is_connected(G))
```

False

In [12]:

```
for u in G.nodes():
    for v in G.nodes():
        print (u, v, nx.has_path(G, u, v))
```

```
Delhi Delhi True
Delhi Trichy True
Delhi Mumbai False
Delhi Tuticorin False
Delhi Chennai False
Delhi Kochi False
Delhi Hyderabad False
Delhi Bangalore False
Delhi Lucknow False
Delhi Amaravati False
Trichy Delhi True
Trichy Trichy True
Trichy Mumbai False
Trichy Tuticorin False
Trichy Chennai False
Trichy Kochi False
Trichy Hyderabad False
Trichy Bangalore False
Trichy Lucknow False
Trichy Amaravati False
Mumbai Delhi False
Mumbai Trichy False
Mumbai Mumbai True
Mumbai Tuticorin True
Mumbai Chennai True
Mumbai Kochi True
Mumbai Hyderabad True
Mumbai Bangalore True
Mumbai Lucknow True
Mumbai Amaravati True
Tuticorin Delhi False
Tuticorin Trichy False
Tuticorin Mumbai True
Tuticorin Tuticorin True
Tuticorin Chennai True
Tuticorin Kochi True
Tuticorin Hyderabad True
Tuticorin Bangalore True
Tuticorin Lucknow True
Tuticorin Amaravati True
Chennai Delhi False
Chennai Trichy False
Chennai Mumbai True
Chennai Tuticorin True
Chennai Chennai True
Chennai Kochi True
Chennai Hyderabad True
Chennai Bangalore True
Chennai Lucknow True
Chennai Amaravati True
Kochi Delhi False
Kochi Trichy False
Kochi Mumbai True
Kochi Tuticorin True
```

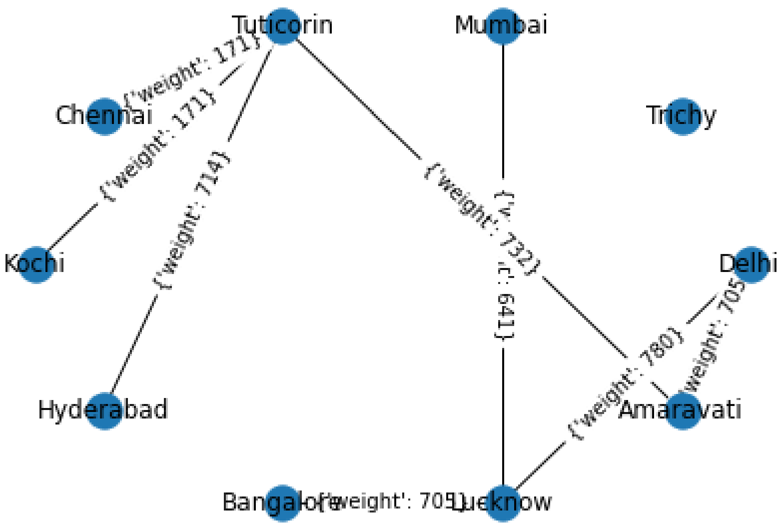
```
Kochi Chennai True
Kochi Kochi True
Kochi Hyderabad True
Kochi Bangalore True
Kochi Lucknow True
Kochi Amaravati True
Hyderabad Delhi False
Hyderabad Trichy False
Hyderabad Mumbai True
Hyderabad Tuticorin True
Hyderabad Chennai True
Hyderabad Kochi True
Hyderabad Hyderabad True
Hyderabad Bangalore True
Hyderabad Lucknow True
Hyderabad Amaravati True
Bangalore Delhi False
Bangalore Trichy False
Bangalore Mumbai True
Bangalore Tuticorin True
Bangalore Chennai True
Bangalore Kochi True
Bangalore Hyderabad True
Bangalore Bangalore True
Bangalore Lucknow True
Bangalore Amaravati True
Lucknow Delhi False
Lucknow Trichy False
Lucknow Mumbai True
Lucknow Tuticorin True
Lucknow Chennai True
Lucknow Kochi True
Lucknow Hyderabad True
Lucknow Bangalore True
Lucknow Lucknow True
Lucknow Amaravati True
Amaravati Delhi False
Amaravati Trichy False
Amaravati Mumbai True
Amaravati Tuticorin True
Amaravati Chennai True
Amaravati Kochi True
Amaravati Hyderabad True
Amaravati Bangalore True
Amaravati Lucknow True
Amaravati Amaravati True
```

5.Build a road network from the created edges

In [14]:

```
#write a module to create the road network
def create_network(cities, costs, numberOfLinks):
    G = nx.Graph()
    for city in cities:
        G.add_node(city)
    while(G.number_of_edges() < numberOfLinks):
        city1 = choice(G.nodes())
        city2 = choice(G.nodes())
        if city1 != city2 and G.has_edge(city1, city2) == 0:
            G.add_edge(city1, city2, weight = choice(costs))
    return G
G = create_network(cities, costs, 8)
print (G.number_of_edges())
pos = nx.circular_layout(G)
nx.draw(G, pos, with_labels=1)
nx.draw_networkx_edge_labels(G, pos)
plt.show()
```

8



In [15]:

```
G.add_edge('Tuticorin', 'Hyderabad', weight = choice(costs))
print (nx.dijkstra_path(G, 'Tuticorin', 'Hyderabad'))# source and destination
print (nx.dijkstra_path_length(G,'Tuticorin', 'Hyderabad'))
```

```
['Tuticorin', 'Hyderabad']
243
```

In [16]:

```
#single source shorest path
print (nx.single_source_dijkstra_path(G, 'Tuticorin'))# source
print (nx.single_source_dijkstra_path_length(G,'Tuticorin'))
```

```
{'Tuticorin': ['Tuticorin'], 'Chennai': ['Tuticorin', 'Chennai'], 'Hyderaba
d': ['Tuticorin', 'Hyderabad'], 'Amaravati': ['Tuticorin', 'Amaravati'], 'Ko
chi': ['Tuticorin', 'Kochi'], 'Delhi': ['Tuticorin', 'Amaravati', 'Delhi'],
'Lucknow': ['Tuticorin', 'Amaravati', 'Delhi', 'Lucknow'], 'Bangalore': ['Tu
ticorin', 'Amaravati', 'Delhi', 'Lucknow', 'Bangalore'], 'Mumbai': ['Tuticor
in', 'Amaravati', 'Delhi', 'Lucknow', 'Mumbai']}
{'Tuticorin': 0, 'Chennai': 171, 'Kochi': 171, 'Hyderabad': 243, 'Amaravat
i': 732, 'Delhi': 1437, 'Lucknow': 2217, 'Mumbai': 2858, 'Bangalore': 2922}
```

Connecting Trichy and Delhi

In [17]:

```
x = [0]
y = [99999999]
cnt  = 0
def make_random_road(cnt):
    cnt = cnt + 1
    city1 = choice(G.nodes())
    city2 = choice(G.nodes())
    wt = choice(costs)
    G.add_edge(city1, city2, weight = wt)
    try:
        distance = nx.dijkstra_path_length(G, 'Trichy', 'Delhi')
        x.append(cnt)
        y.append(distance)
        return cnt
    except:
        print (cnt, "Still no path....")
        x.append(cnt)
        y.append(99999999)
        cnt += 1
        make_random_road(cnt)
```

In [18]:

```
make_random_road(0)
```

```
1 Still no path....
```

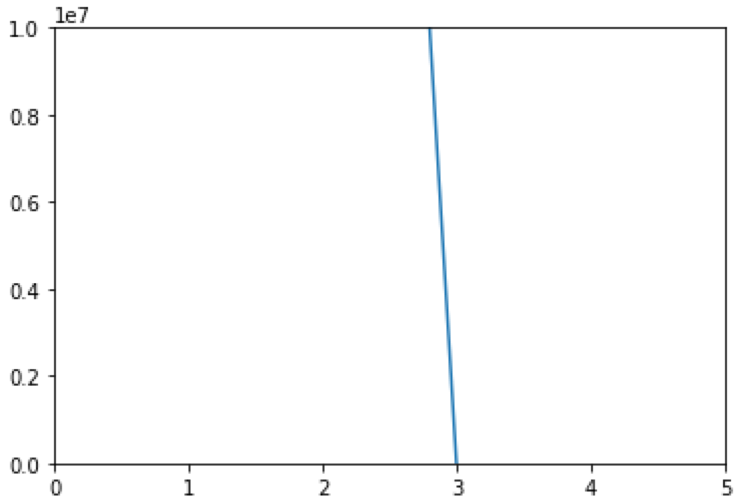
In [19]:

```
print (nx.dijkstra_path(G, 'Delhi', 'Trichy'))
print (nx.dijkstra_path_length(G, 'Delhi', 'Trichy'))
```

```
['Delhi', 'Lucknow', 'Bangalore', 'Trichy']
1656
```

In [20]:

```
plt.plot(x, y)
plt.axis([0,5,0,10000000])
plt.show()
```



Excercise 2

Using txt file

In [21]:

```
#datasets.py
import networkx as nx
import matplotlib.pyplot as plt

G = nx.read_edgelist('facebook_combined.txt')

print (nx.info(G))
```

```
Graph with 4039 nodes and 88234 edges
```

In [22]:

```
print (nx.number_of_nodes(G))
print (nx.number_of_edges(G))
print (nx.is_directed(G))
```

```
4039
88234
False
```

pajek

In [23]:

```
G2 = nx.read_pajek("football.net") #.net
print (nx.info(G2))
print (nx.number_of_nodes(G2))
print (nx.number_of_edges(G2))
print (nx.is_directed(G2))
```

```
MultiDiGraph with 35 nodes and 118 edges
35
118
True
```

In [24]:

```
G3 = nx.read_pajek("karate.paj")
print (nx.info(G3))
print (nx.number_of_nodes(G3))
print (nx.number_of_edges(G3))
print (nx.is_directed(G3))
```

```
MultiGraph with 34 nodes and 78 edges
34
78
False
```

In [25]:

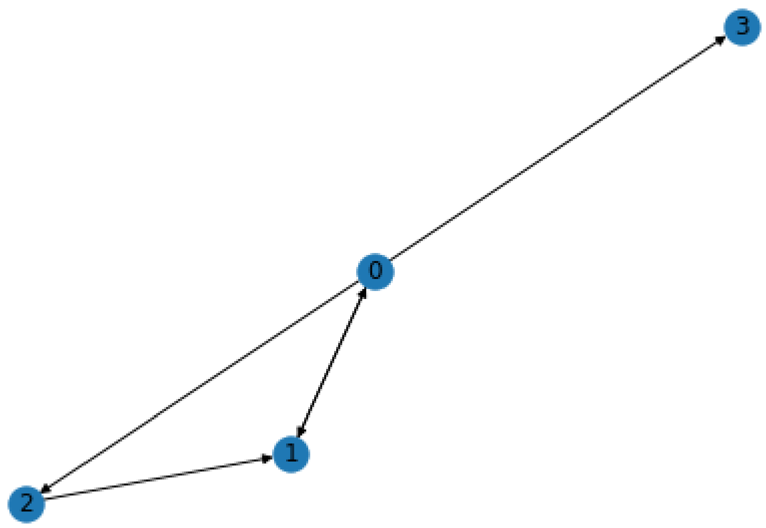
```
G4 = nx.read_graphml("wikipedia.graphml")
print (nx.info(G4))
print (nx.number_of_nodes(G4))
print (nx.number_of_edges(G4))
print (nx.is_directed(G4))
```

```
DiGraph with 921 nodes and 1081 edges
921
1081
True
```

In [26]:

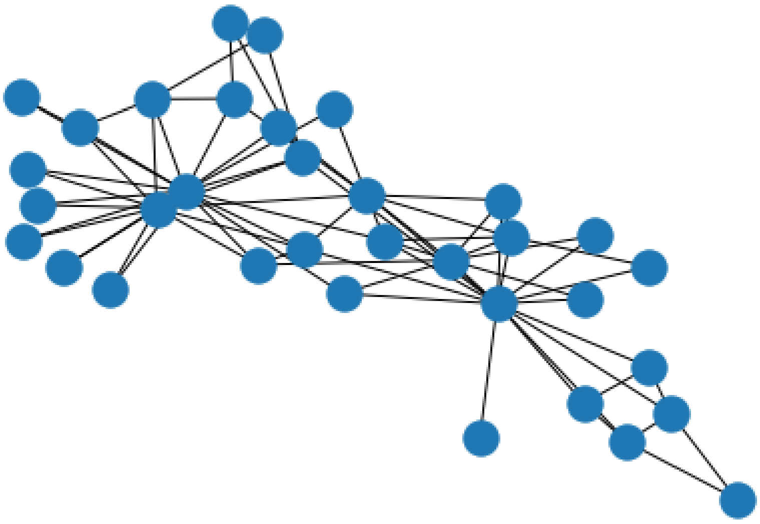
```
G5 = nx.read_gexf("data.gexf")
print (nx.info(G5))
print (nx.is_directed(G5))
nx.draw(G5,with_labels=1)
plt.show()
```

```
DiGraph with 4 nodes and 5 edges
True
```



In [27]:

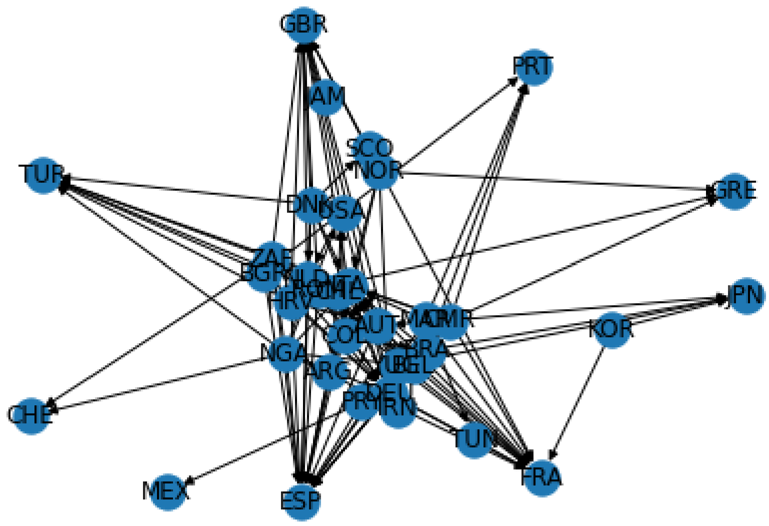
```
G6 = nx.read_gml('karate.gml',label='id')
nx.draw(G6)
plt.show()
```

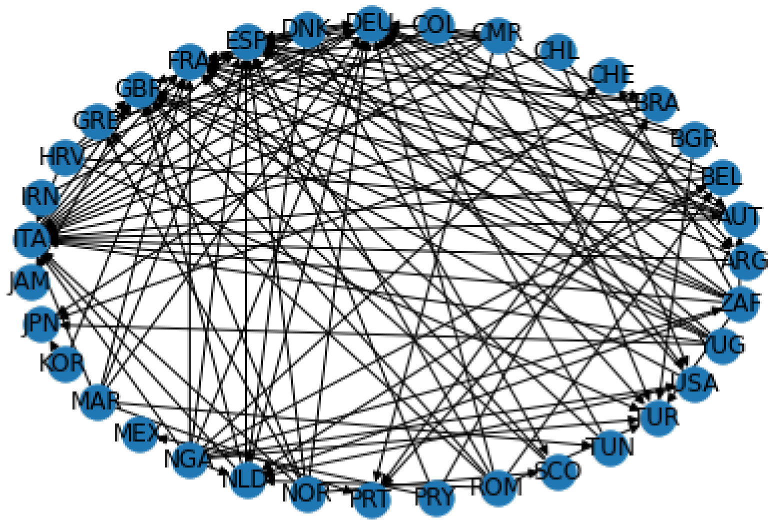


In [28]:

```
print (nx.info(G2))#football.net
nx.draw(G2, with_labels=1)
plt.show()
nx.draw_circular(G2, with_labels=1)
plt.show()
```

```
MultiDiGraph with 35 nodes and 118 edges
```

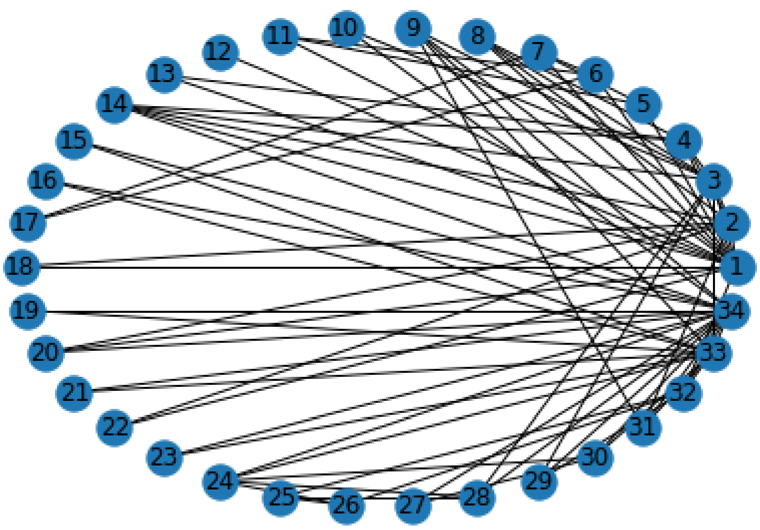




In [29]:

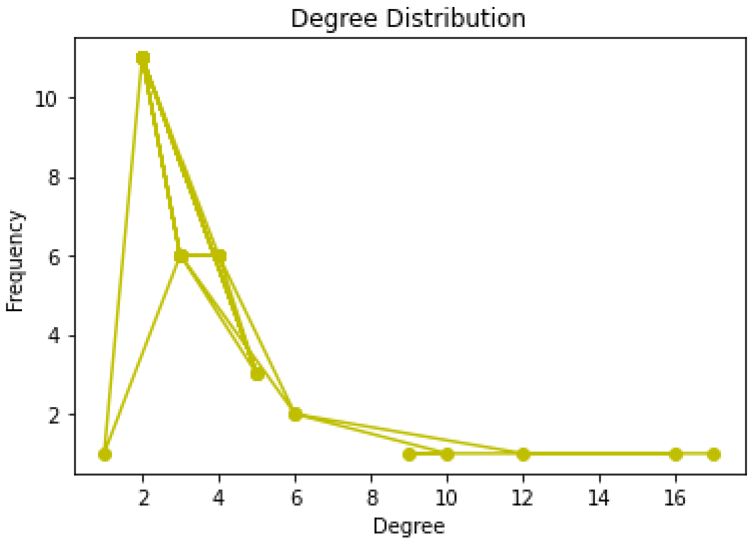
```
#Analysis of karate.gml G6
nx.draw_circular(G6, with_labels=1)
plt.show()
# Degree Distribution (degree and no. of nodes)
print (nx.degree(G6))
all_degree_list = dict(nx.degree(G6)).values()
print (all_degree_list)

def degree_distribution(G6):
    #finding unique factors
    degree_count = []
    deg_set = dict(nx.degree(G6)).values()
    unique_deg_list = list(deg_set)
    print ("Degree List : ", unique_deg_list)
    for i in unique_deg_list:
        x = list(all_degree_list).count(i)
        degree_count.append(x)
    plt.plot(unique_deg_list, degree_count, 'yo-')
    plt.xlabel("Degree")
    plt.ylabel("Frequency")
    plt.title("Degree Distribution")
    plt.show()
    return
degree_distribution(G6) #Implies it follows power law degree distributiom
# power law - Only few nodes have higher degrees
```




```
[(1, 16), (2, 9), (3, 10), (4, 6), (5, 3), (6, 4), (7, 4), (8, 4), (9, 5),
(10, 2), (11, 3), (12, 1), (13, 2), (14, 5), (15, 2), (16, 2), (17, 2), (18,
2), (19, 2), (20, 3), (21, 2), (22, 2), (23, 2), (24, 5), (25, 3), (26, 3),
(27, 2), (28, 4), (29, 3), (30, 4), (31, 4), (32, 6), (33, 12), (34, 17)]
dict_values([16, 9, 10, 6, 3, 4, 4, 4, 5, 2, 3, 1, 2, 5, 2, 2, 2, 2, 2, 3,
```

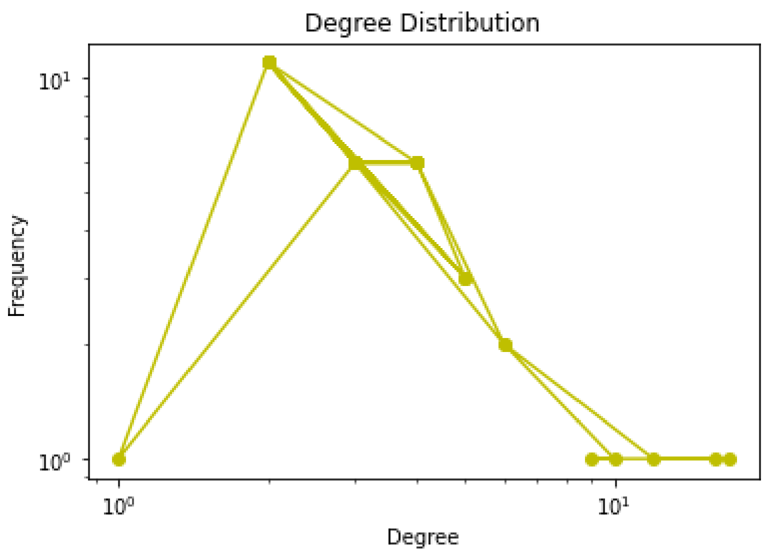
```
2, 2, 2, 5, 3, 3, 2, 4, 3, 4, 4, 6, 12, 17])
Degree List :  [16, 9, 10, 6, 3, 4, 4, 4, 5, 2, 3, 1, 2, 5, 2, 2, 2, 2, 2,
3, 2, 2, 2, 5, 3, 3, 2, 4, 3, 4, 4, 6, 12, 17]
```



In [30]:

```
def degree_distribution(G):
    degree_count = []
    #finding unique factors
    deg_set = dict(nx.degree(G6)).values()
    unique_deg_list = list(deg_set)
    print ("Degree List : ", unique_deg_list)
    for i in unique_deg_list:
        x = list(all_degree_list).count(i)
        degree_count.append(x)
    print ("unique degree list : ", unique_deg_list)
    print ("degree count : ", degree_count)
    plt.loglog(unique_deg_list, degree_count, 'yo-')#plot between logx and logy
    plt.xlabel("Degree")
    plt.ylabel("Frequency")
    plt.title("Degree Distribution")
    plt.show()
    return
degree_distribution(G6)
```

```
Degree List :  [16, 9, 10, 6, 3, 4, 4, 4, 5, 2, 3, 1, 2, 5, 2, 2, 2, 2, 2,
3, 2, 2, 2, 5, 3, 3, 2, 4, 3, 4, 4, 6, 12, 17]
unique degree list :  [16, 9, 10, 6, 3, 4, 4, 4, 5, 2, 3, 1, 2, 5, 2, 2, 2,
2, 2, 3, 2, 2, 2, 5, 3, 3, 2, 4, 3, 4, 4, 6, 12, 17]
degree count :  [1, 1, 1, 2, 6, 6, 6, 6, 3, 11, 6, 1, 11, 3, 11, 11, 11, 11,
11, 6, 11, 11, 11, 3, 6, 6, 11, 6, 6, 6, 6, 2, 1, 1]
```



Density

- density = number of edges present/Total edges possible
- max edges = n (C) 2
- simple graph -> density 0 to 1
- null graph -> density = 0
- complete graph -> density = 1
- multi graph -> density >=0

In [31]:

```
G  = nx.complete_graph(100)
print (nx.density(G))
G = nx.Graph()
G.add_nodes_from([1, 2, 3, 4])
print (nx.density(G))
```

```
1.0
0
```

In [32]:

```
#density of karate
print (nx.density(G6)) #=> sparse graph
```

```
0.13903743315508021
```

Clustering Coefficient

- clustering coef = number of direct friendships among neighbours / Total possible friendships among neighbours
- Avg clustering coef

In [33]:

```
print (nx.clustering(G6))
```

```
{1: 0.15, 2: 0.3333333333333333, 3: 0.24444444444444444, 4: 0.66666666666666
66, 5: 0.6666666666666666, 6: 0.5, 7: 0.5, 8: 1.0, 9: 0.5, 10: 0, 11: 0.6666
666666666666, 12: 0, 13: 1.0, 14: 0.6, 15: 1.0, 16: 1.0, 17: 1.0, 18: 1.0, 1
9: 1.0, 20: 0.3333333333333333, 21: 1.0, 22: 1.0, 23: 1.0, 24: 0.4, 25: 0.33
33333333333333, 26: 0.3333333333333333, 27: 1.0, 28: 0.16666666666666666, 2
9: 0.3333333333333333, 30: 0.6666666666666666, 31: 0.5, 32: 0.2, 33: 0.19696
969696969696, 34: 0.11029411764705882}
```

In [34]:

```
for i in nx.clustering(G6).items():
    print (i)
print ("Avg clustering : ", nx.average_clustering(G6))
```

```
(1, 0.15)
(2, 0.3333333333333333)
(3, 0.24444444444444444)
(4, 0.6666666666666666)
(5, 0.6666666666666666)
(6, 0.5)
(7, 0.5)
(8, 1.0)
(9, 0.5)
(10, 0)
(11, 0.6666666666666666)
(12, 0)
(13, 1.0)
(14, 0.6)
(15, 1.0)
(16, 1.0)
(17, 1.0)
(18, 1.0)
(19, 1.0)
(20, 0.3333333333333333)
(21, 1.0)
(22, 1.0)
(23, 1.0)
(24, 0.4)
(25, 0.3333333333333333)
(26, 0.3333333333333333)
(27, 1.0)
(28, 0.16666666666666666)
(29, 0.3333333333333333)
(30, 0.6666666666666666)
(31, 0.5)
(32, 0.2)
(33, 0.19696969696969696)
(34, 0.11029411764705882)
Avg clustering :  0.5706384782076823
```

Diameter

- diameter = max shortest path between any nodes in a network

In [35]:

```
print ("Diameter is", nx.diameter(G6))
```

```
Diameter is 5
```