```
In [1]: import pandas as pd

        #            CSV            DataFrame
        data = pd.read_csv('/content/202212-divvy-tripdata.csv')


        #
        print(data.head())
        #         1: shape
        row_count = data.shape[0]

        #         2: len()
        row_count = len(data)

        #
        print("        ", row_count)
```

```
            ride_id  rideable_type           started_at             ended_at
0  65DBD2F447EC51C2  electric_bike  2022-12-05 10:47:18  2022-12-05 10:56:34
1  0C201AA7EA0EA1AD   classic_bike  2022-12-18 06:42:33  2022-12-18 07:08:44
2  E0B148CCB358A49D  electric_bike  2022-12-13 08:47:45  2022-12-13 08:59:51
3  54C5775D2B7C9188   classic_bike  2022-12-13 18:50:47  2022-12-13 19:19:48
4  A4891F78776D35DF   classic_bike  2022-12-14 16:13:39  2022-12-14 16:27:50

           start_station_name start_station_id           end_station_name  \
0  Clifton Ave & Armitage Ave     TA1307000163  Sedgwick St & Webster Ave
1      Broadway & Belmont Ave            13277  Sedgwick St & Webster Ave
2       Sangamon St & Lake St     TA1306000015     St. Clair St & Erie St
3       Shields Ave & 31st St     KA1503000038     Damen Ave & Madison St
4   Ashland Ave & Chicago Ave            13247  Damen Ave & Charleston St

  end_station_id  start_lat  start_lng    end_lat    end_lng member_casual
0          13191  41.918244 -87.657115  41.922167 -87.638888        member
1          13191  41.940106 -87.645451  41.922167 -87.638888        casual
2          13016  41.885919 -87.651133  41.894345 -87.622798        member
3          13134  41.838464 -87.635406  41.881370 -87.674930        member
4          13288  41.895954 -87.667728  41.920082 -87.677855        casual
               : 181806
```

```
In [2]: print(data.head())
        print(data.info())
```

```
            ride_id  rideable_type           started_at             ended_at
0  65DBD2F447EC51C2  electric_bike  2022-12-05 10:47:18  2022-12-05 10:56:34
1  0C201AA7EA0EA1AD   classic_bike  2022-12-18 06:42:33  2022-12-18 07:08:44
2  E0B148CCB358A49D  electric_bike  2022-12-13 08:47:45  2022-12-13 08:59:51
3  54C5775D2B7C9188   classic_bike  2022-12-13 18:50:47  2022-12-13 19:19:48
4  A4891F78776D35DF   classic_bike  2022-12-14 16:13:39  2022-12-14 16:27:50

           start_station_name start_station_id           end_station_name  \
0  Clifton Ave & Armitage Ave     TA1307000163  Sedgwick St & Webster Ave
1      Broadway & Belmont Ave            13277  Sedgwick St & Webster Ave
2       Sangamon St & Lake St     TA1306000015     St. Clair St & Erie St
3       Shields Ave & 31st St     KA1503000038     Damen Ave & Madison St
4   Ashland Ave & Chicago Ave            13247  Damen Ave & Charleston St

  end_station_id  start_lat  start_lng    end_lat    end_lng member_casual
0          13191  41.918244 -87.657115  41.922167 -87.638888        member
1          13191  41.940106 -87.645451  41.922167 -87.638888        casual
2          13016  41.885919 -87.651133  41.894345 -87.622798        member
3          13134  41.838464 -87.635406  41.881370 -87.674930        member
4          13288  41.895954 -87.667728  41.920082 -87.677855        casual
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 181806 entries, 0 to 181805
Data columns (total 13 columns):
 #   Column              Non-Null Count   Dtype
---  ------              --------------   -----
 0   ride_id             181806 non-null  object
 1   rideable_type       181806 non-null  object
 2   started_at          181806 non-null  object
 3   ended_at            181806 non-null  object
 4   start_station_name  152523 non-null  object
 5   start_station_id    152523 non-null  object
 6   end_station_name    150648 non-null  object
 7   end_station_id      150648 non-null  object
 8   start_lat           181806 non-null  float64
 9   start_lng           181806 non-null  float64
 10  end_lat             181678 non-null  float64
 11  end_lng             181678 non-null  float64
 12  member_casual       181806 non-null  object
dtypes: float64(4), object(9)
memory usage: 18.0+ MB
None
```

```
In [3]: #
        print(data.duplicated().sum())

        # 'started_at'         'ended_at'
        print(data['started_at'].max())
        print(data['ended_at'].max())
```

```
0
2022-12-31 23:59:26
2023-01-02 04:56:45
```

```
In [4]: #
        print(data.isnull().sum())
```

```
ride_id                   0
rideable_type             0
started_at                0
ended_at                  0
start_station_name    29283
start_station_id      29283
end_station_name      31158
end_station_id        31158
start_lat                 0
start_lng                 0
end_lat                 128
end_lng                 128
member_casual             0
dtype: int64
```

```
In [5]: #
        unique_start_stations = data.dropna(subset=['start_station_name', 'start_
        unique_end_stations = data.dropna(subset=['end_station_name', 'end_statio

        #
        for index, row in data.iterrows():
            if pd.isnull(row['start_station_name']) or pd.isnull(row['start_statio
                match = unique_start_stations[(unique_start_stations['start_lat']
                if not match.empty:
                    data.at[index, 'start_station_name'] = match.iloc[0]['start_s
                    data.at[index, 'start_station_id'] = match.iloc[0]['start_sta

        #
        for index, row in data.iterrows():
            if pd.isnull(row['end_station_name']) or pd.isnull(row['end_station_i
                match = unique_end_stations[(unique_end_stations['end_lat'] == ro
                if not match.empty:
                    data.at[index, 'end_station_name'] = match.iloc[0]['end_static
                    data.at[index, 'end_station_id'] = match.iloc[0]['end_station_
```

```
In [6]: #
        print(data.isnull().sum())
```

```
ride_id                   0
rideable_type             0
started_at                0
ended_at                  0
start_station_name    18896
start_station_id      18896
end_station_name      20230
end_station_id        20230
start_lat                 0
start_lng                 0
end_lat                 128
end_lng                 128
member_casual             0
dtype: int64
```

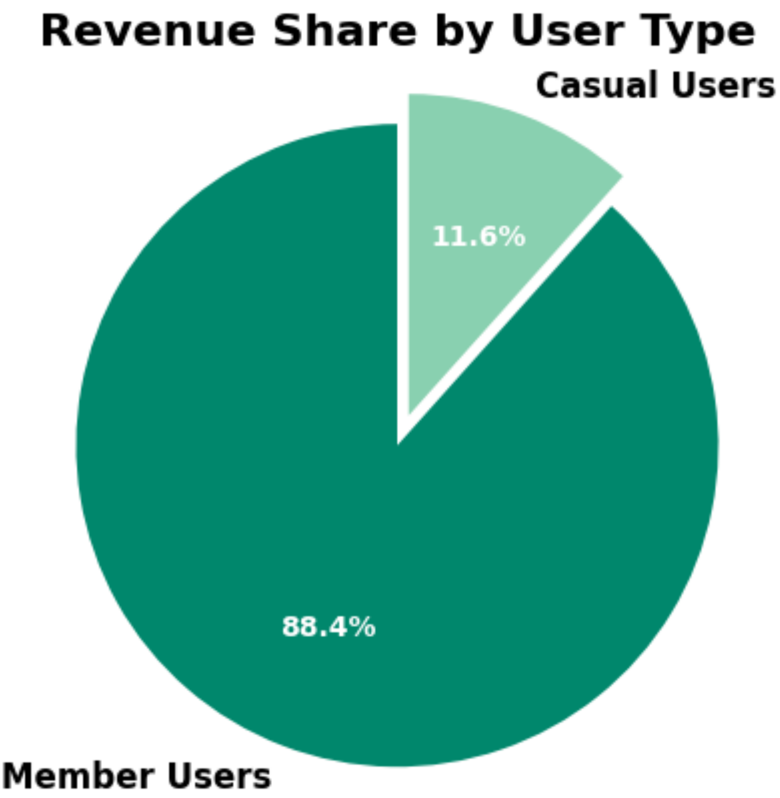
```
In [8]: #
        data['started_at'] = pd.to_datetime(data['started_at'])
        data['ended_at'] = pd.to_datetime(data['ended_at'])
```

```
In [9]: #
        data['trip_duration']= data['ended_at'] - data['started_at']
```

In [20]:
```
#
member_rate_per_week = 25  #
casual_rate_per_minute = 0.45  #

# 'trip_duration'
data['trip_duration_seconds'] = data['trip_duration'].dt.total_seconds()

#
member_revenue = data[data['member_casual'] == 'member'].shape[0] * membe

#
casual_revenue = (data[data['member_casual'] == 'casual']['trip_duration_

#
print(f"            {member_revenue:$,.2f}")
print(f"             {casual_revenue:$,.2f}")
```

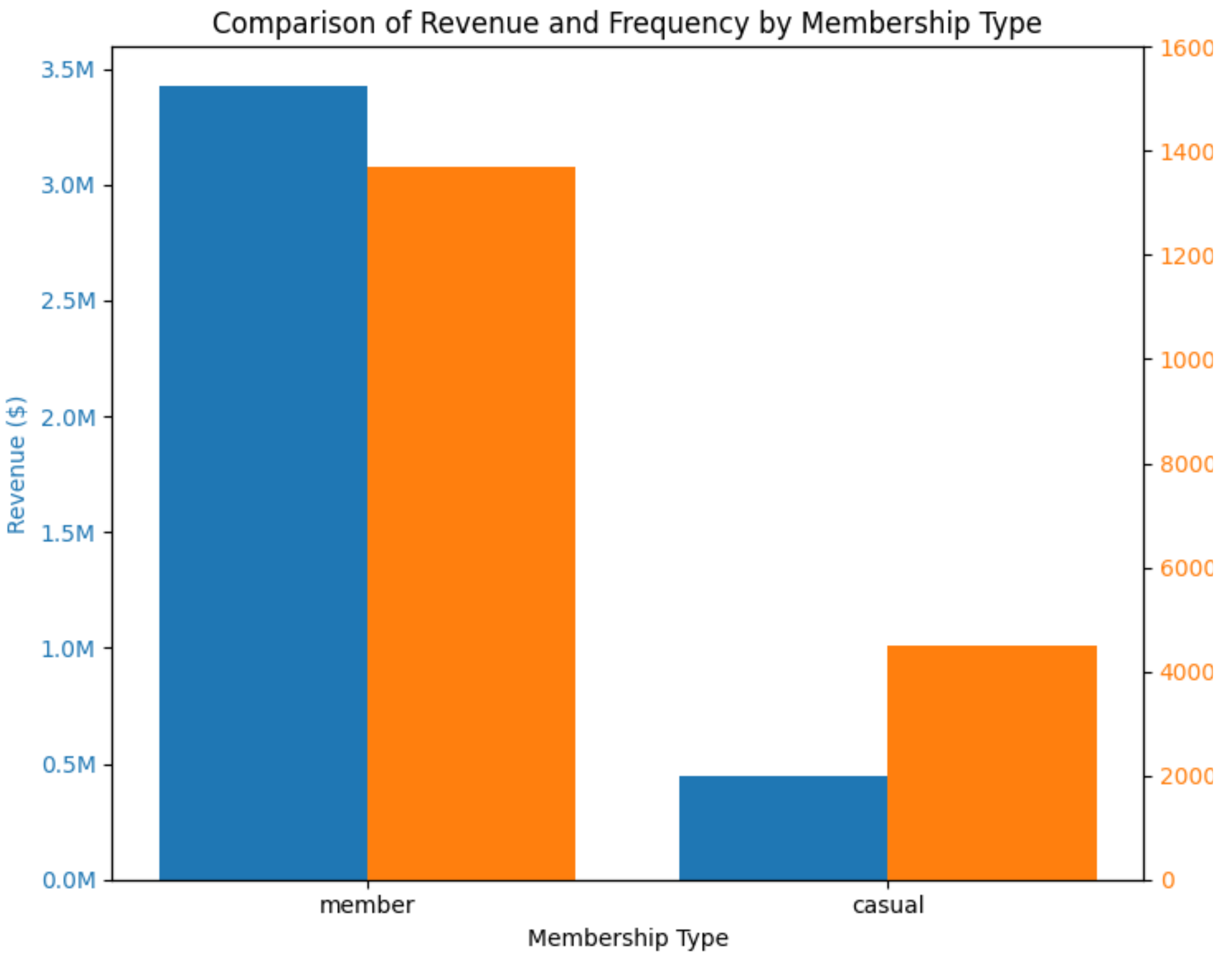
```
                        : $3,422,800.00
                            : $450,300.46
```

In [21]:
```
import matplotlib.pyplot as plt

#
revenues = [member_revenue, casual_revenue]
labels = ['Member Users', 'Casual Users']
explode = (0.1, 0)  # Only pop out the Member Users segment
colors = ['#00876c', '#89d0b0']  # Sophisticated green color palette


#
fig, ax = plt.subplots()
wedges, texts, autotexts = ax.pie(revenues, explode=explode, labels=label
                                   startangle=90, colors=colors, textprop

#
plt.setp(texts, size=12, weight="bold", color="black")
plt.setp(autotexts, size=10, weight="bold")

#
ax.axis('equal')

#
plt.title('Revenue Share by User Type', fontdict={'fontsize': 16, 'fontwe

#
plt.show()
```



```
In [22]: member_usage_frequency = data[data['member_casual'] == 'member'].shape[0]
         casual_usage_frequency = data[data['member_casual'] == 'casual'].shape[0]
         #
         print("                       :", member_usage_frequency)
         print("                         :", casual_usage_frequency)

         print("            가:",member_revenue/member_usage_frequency)
         print("              가:",casual_revenue/casual_usage_frequency)
                                          : 136912
                                              : 44894
                          가: 25.0
                              가: 10.030303938165456
```

```
In [23]: import matplotlib.pyplot as plt

         # 'member'    'casual'                   (revenues)                   (fre
         #
         revenues = [member_revenue,
                     casual_revenue]
         frequencies = [data[data['member_casual'] == 'member'].shape[0],
                        data[data['member_casual'] == 'casual'].shape[0]]

         categories = ['member', 'casual']
         positions = range(len(categories))
         width = 0.4  #

         fig, ax1 = plt.subplots(figsize=(8, 6))

         # Revenue (       )
         color = 'tab:blue'
         ax1.set_xlabel('Membership Type')
         ax1.set_ylabel('Revenue ($)', color=color)
         ax1.bar([p - width/2 for p in positions], revenues, width=width, color=co
         ax1.tick_params(axis='y', labelcolor=color)

         #         y                          'M'    가
         def millions_formatter(x, pos):
             return f'{x / 1_000_000}M'
         ax1.yaxis.set_major_formatter(plt.FuncFormatter(millions_formatter))

         # Frequency (               )                          , y
         ax2 = ax1.twinx()
         color = 'tab:orange'
         ax2.set_ylabel('Frequency', color=color)
         ax2.bar([p + width/2 for p in positions], frequencies, width=width, color=
         ax2.tick_params(axis='y', labelcolor=color)
         ax2.set_ylim(0, 160000)  # y                0       160,000

         # x
         ax1.set_xticks(positions)
         ax1.set_xticklabels(categories)

         plt.title('Comparison of Revenue and Frequency by Membership Type')
         fig.tight_layout()

         #
         plt.show()
```



```
In [24]: # 'rideable_type'
         bike_type_counts = data['rideable_type'].value_counts(normalize=True) * 1

         #
         bike_type_counts
```

```
Out[24]: electric_bike    58.595976
         classic_bike     40.345203
         docked_bike       1.058821
         Name: rideable_type, dtype: float64
```

```
In [25]: #                          electric_bike    classic_bike
         station_bike_usage = data.groupby(['start_station_id', 'rideable_type']).

         # electric_bike    classic_bike
         station_bike_usage = station_bike_usage[['electric_bike', 'classic_bike']]

         #                                                                   20
         top_20_stations = station_bike_usage.sum(axis=1).nlargest(20).index

         #         20                              electric_bike    classic_bike
         top_20_station_usage = station_bike_usage.loc[top_20_stations]

         #
         print(top_20_station_usage)
```

```
rideable_type     electric_bike  classic_bike
start_station_id
KA1503000043                699           715
WL-012                      778           547
TA1307000039                466           756
21544                       543           623
TA1305000032                626           435
13011                       527           511
TA1308000050                562           471
TA1306000012                471           551
KA1504000135                514           506
TA1306000009                538           462
638                         518           446
TA1307000117                473           470
13016                       441           472
KA1503000071                254           641
13430                       493           400
13045                       411           478
TA1306000003                463           406
TA1307000151                441           419
13137                       389           469
KA1503000014                208           644
```

```
In [26]: data.dropna(inplace=True)

         row_count = data.shape[0]

         #         2: len()
         row_count = len(data)

         #
         print("        , row_count)
```

```
                 : 149665
```

```
In [27]: trip_data = data[['started_at', 'ended_at', 'trip_duration']]
```

```
In [28]: trip_data['trip_duration'].min()
```

```
Out[28]: Timedelta('0 days 00:00:00')
```

```
In [29]: # 'trip_duration'
         negative_duration_data = data[data['trip_duration'] < pd.Timedelta(0)]

         #
         print(negative_duration_data)
```

```
Empty DataFrame
Columns: [ride_id, rideable_type, started_at, ended_at, start_station_name,
start_station_id, end_station_name, end_station_id, start_lat, start_lng, end
end_lng, member_casual, trip_duration, route, day_of_week, trip_duration_seco
Index: []
```

```
In [30]: number_of_rows =len(negative_duration_data)
         number_of_rows
```

```
Out[30]: 0
```

```
In [31]: data['trip_duration'].describe()
```

Out[31]:
```
count                            149665
mean      0 days 00:11:12.016817559
std       0 days 00:24:16.775265530
min                 0 days 00:00:00
25%                 0 days 00:04:37
50%                 0 days 00:07:35
75%                 0 days 00:12:40
max                 1 days 00:59:52
Name: trip_duration, dtype: object
```

In [32]:
```
ratio_caual_member=casual_usage_frequency/(member_usage_frequency + casua
ratio_caual_member
```

Out[32]:
```
0.24693354454748467
```

In [33]:
```
data.head()
```

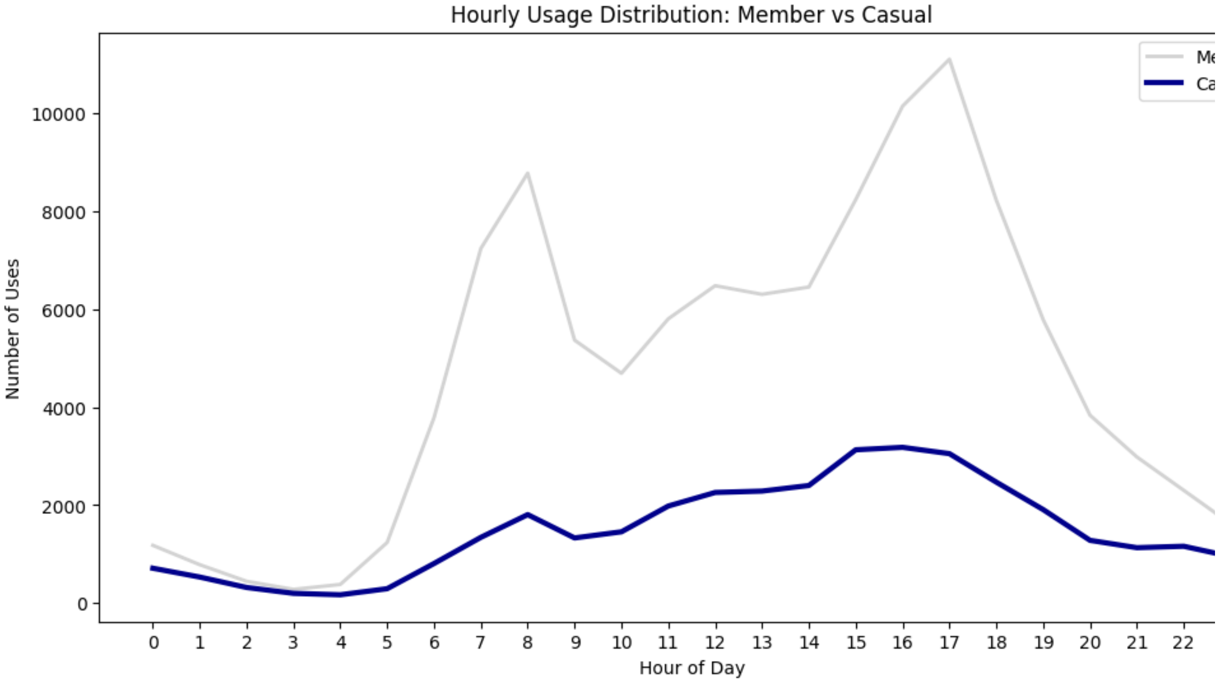
Out[33]:

| | ride_id | rideable_type | started_at | ended_at | start_station_name | start_s |
|---|---|---|---|---|---|---|
| **0** | 65DBD2F447EC51C2 | electric_bike | 2022-12-05 10:47:18 | 2022-12-05 10:56:34 | Clifton Ave & Armitage Ave | TA13 |
| **1** | 0C201AA7EA0EA1AD | classic_bike | 2022-12-18 06:42:33 | 2022-12-18 07:08:44 | Broadway & Belmont Ave | |
| **2** | E0B148CCB358A49D | electric_bike | 2022-12-13 08:47:45 | 2022-12-13 08:59:51 | Sangamon St & Lake St | TA13 |
| **3** | 54C5775D2B7C9188 | classic_bike | 2022-12-13 18:50:47 | 2022-12-13 19:19:48 | Shields Ave & 31st St | KA15 |
| **4** | A4891F78776D35DF | classic_bike | 2022-12-14 16:13:39 | 2022-12-14 16:27:50 | Ashland Ave & Chicago Ave | |

```
In [34]: #                   (      )    가
         data['hour_of_day'] = data['started_at'].dt.hour

         #
         member_hour_usage = data[data['member_casual'] == 'member']['hour_of_day'
         casual_hour_usage = data[data['member_casual'] == 'casual']['hour_of_day'

         #
         member_start_stations = data[data['member_casual'] == 'member']['start_sta
         casual_start_stations = data[data['member_casual'] == 'casual']['start_sta

         #
         print("             \n", member_hour_usage)
         print("\n              \n", casual_hour_usage)
         print("\n              \n", member_start_stations.head())
         print("\n               \n", casual_start_stations.head(10))
```

```
                                 :
 0      1181
1        786
2        447
3        282
4        383
5       1239
6       3785
7       7240
8       8777
9       5369
10      4692
11      5804
12      6480
13      6304
14      6452
15      8237
16     10145
17     11102
18      8225
19      5788
20      3837
21      2985
22      2304
23      1621
Name: hour_of_day, dtype: int64

                                    :
 0      714
1       534
2       321
3       201
4       172
5       296
6       810
7      1344
8      1808
9      1332
10     1457
11     1983
12     2260
13     2288
14     2402
15     3131
16     3181
17     3052
18     2471
19     1911
20     1283
21     1133
22     1162
23      954
Name: hour_of_day, dtype: int64

                                    :
 Kingsbury St & Kinzie St        1107
Clinton St & Washington Blvd    1092
Clark St & Elm St                932
State St & Chicago Ave           928
Canal St & Adams St              828
Name: start_station_name, dtype: int64
```

```
In [35]: import matplotlib.pyplot as plt

         plt.figure(figsize=(12, 6))

         #                    -
         plt.plot(member_hour_usage, label='Member', color='lightgray', linewidth=2

         #                       -
         plt.plot(casual_hour_usage, label='Casual', color='darkblue', linewidth=3

         plt.title('Hourly Usage Distribution: Member vs Casual')
         plt.xlabel('Hour of Day')
         plt.ylabel('Number of Uses')
         plt.xticks(range(0, 24))
         plt.legend()
         plt.show()
```



```
In [36]: #
         stations = [ 'Shedd Aquarium',
         'Streeter Dr & Grand Ave',
         'Millennium Park',
         'DuSable Lake Shore Dr & Monroe St',
         'Kingsbury St & Kinzie St',
         'Clark St & Newport St',
         'LaSalle St & Illinois St',
         'Clark St & Elm St',
         'Wabash Ave & Grand Ave',
         'Michigan Ave & 8th St'

         ]

         #
         station_coordinates = {}
         for station in stations:
             station_data = data[data['start_station_name'] == station].iloc[0]
             station_coordinates[station] = {
                 'start_lat': station_data['start_lat'],
                 'start_lng': station_data['start_lng']
             }

         #
         for station, coords in station_coordinates.items():
             print(f"{station}:    {coords['start_lat']},    {coords['start_lng']}")
```

```
Shedd Aquarium:         41.86722595682,         -87.6153553902
Streeter Dr & Grand Ave:         41.892271399,         -87.612205386
Millennium Park:         41.8810317,         -87.62408432
DuSable Lake Shore Dr & Monroe St:         41.880958,         -87.616743
Kingsbury St & Kinzie St:         41.889224052,         -87.638541102
Clark St & Newport St:         41.94444816666667,         -87.65470916666666
LaSalle St & Illinois St:         41.89066016666666,         -87.6314525
Clark St & Elm St:         41.90281866666667,         -87.6316435
Wabash Ave & Grand Ave:         41.891783953,         -87.626822114
Michigan Ave & 8th St:         41.872773,         -87.623981
```

In [37]:

```python
import math
import pandas as pd
# Haversine
def haversine(lat1, lon1, lat2, lon2):
    #                 (km        )
    R = 6371.0

    #        ,
    lat1 = math.radians(lat1)
    lon1 = math.radians(lon1)
    lat2 = math.radians(lat2)
    lon2 = math.radians(lon2)

    #
    dlat = lat2 - lat1
    dlon = lon2 - lon1

    # Haversine
    a = math.sin(dlat / 2)**2 + math.cos(lat1) * math.cos(lat2) * math.si
    c = 2 * math.atan2(math.sqrt(a), math.sqrt(1 - a))

    #
    distance = R * c
    return distance

#
data['distance'] = data.apply(lambda row: haversine(row['start_lat'], row

#
print(data[['start_lat', 'start_lng', 'end_lat', 'end_lng', 'distance']].
```

```
   start_lat  start_lng    end_lat    end_lng  distance
0  41.918244 -87.657115  41.922167 -87.638888  1.569868
1  41.940106 -87.645451  41.922167 -87.638888  2.067289
2  41.885919 -87.651133  41.894345 -87.622798  2.525678
3  41.838464 -87.635406  41.881370 -87.674930  5.785813
4  41.895954 -87.667728  41.920082 -87.677855  2.810713
```

In [38]:

```python
# 'distance'
member_avg_distance = data[data['member_casual'] == 'member']['distance']
casual_avg_distance = data[data['member_casual'] == 'casual']['distance']

#
print(f"               {member_avg_distance}:km")
print(f"                {casual_avg_distance} km")
```

```
                                      : 1.7848778675208914 km
                                         : 1.7099901360039518 km
```

In [39]:

```python
data.head()
```

Out[39]:

|  | ride_id | rideable_type | started_at | ended_at | start_station_name | start_s |
|---|---|---|---|---|---|---|
| **0** | 65DBD2F447EC51C2 | electric_bike | 2022-12-05 10:47:18 | 2022-12-05 10:56:34 | Clifton Ave & Armitage Ave | TA130 |
| **1** | 0C201AA7EA0EA1AD | classic_bike | 2022-12-18 06:42:33 | 2022-12-18 07:08:44 | Broadway & Belmont Ave |  |
| **2** | E0B148CCB358A49D | electric_bike | 2022-12-13 08:47:45 | 2022-12-13 08:59:51 | Sangamon St & Lake St | TA130 |
| **3** | 54C5775D2B7C9188 | classic_bike | 2022-12-13 18:50:47 | 2022-12-13 19:19:48 | Shields Ave & 31st St | KA150 |
| **4** | A4891F78776D35DF | classic_bike | 2022-12-14 16:13:39 | 2022-12-14 16:27:50 | Ashland Ave & Chicago Ave |  |

In [40]:

```
# 'start_station_name'    'end_station_name'
data['route'] = data['start_station_name'] + " to " + data['end_station_na

#                                        가
member_routes = data[data['member_casual'] == 'member']['route'].value_co
casual_routes = data[data['member_casual'] == 'casual']['route'].value_co

#
print("                \n", member_routes)       :
print("                 \n", casual_routes)         :
```

```
                                            :
 University Ave & 57th St to Ellis Ave & 60th St     232
Ellis Ave & 60th St to University Ave & 57th St     221
Ellis Ave & 60th St to Ellis Ave & 55th St          198
Calumet Ave & 33rd St to State St & 33rd St         191
Ellis Ave & 55th St to Ellis Ave & 60th St          184
State St & 33rd St to Calumet Ave & 33rd St         181
Loomis St & Lexington St to Morgan St & Polk St     108
State St & Chicago Ave to State St & Chicago Ave    105
Morgan St & Polk St to Loomis St & Lexington St     102
MLK Jr Dr & 29th St to State St & 33rd St            93
Name: route, dtype: int64
                                               :
 Streeter Dr & Grand Ave to Streeter Dr & Grand Ave                       69
DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe St    64
DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave              58
Shedd Aquarium to DuSable Lake Shore Dr & Monroe St                       57
Millennium Park to Millennium Park                                        55
W Washington Blvd & N Peoria St to W Washington Blvd & N Peoria St        51
Shedd Aquarium to Shedd Aquarium                                          50
Shedd Aquarium to Streeter Dr & Grand Ave                                 47
DuSable Lake Shore Dr & Monroe St to Shedd Aquarium                       44
University Ave & 57th St to Ellis Ave & 60th St                           39
Name: route, dtype: int64
```

```
In [41]: # 'route'
data['route'] = data['start_station_name'] + " to " + data['end_station_na

#                                          가
member_routes = data[data['member_casual'] == 'member']['route'].value_co
casual_routes = data[data['member_casual'] == 'casual']['route'].value_co

#
def get_route_coordinates(data, top_routes):
    route_coordinates = {}
    for route in top_routes.index:
        start_station, end_station = route.split(" to ")
        start_coords = data[data['start_station_name'] == start_station][
        end_coords = data[data['end_station_name'] == end_station][['end_
        route_coordinates[route] = (start_coords.tolist(), end_coords.tol
    return route_coordinates

#
member_route_coords = get_route_coordinates(data, member_routes)

#
casual_route_coords = get_route_coordinates(data, casual_routes)

#
print("                    \n", member_route_coords)      :
print("                     \n", casual_route_coords)        :
```

```
                                                    :
 {'University Ave & 57th St to Ellis Ave & 60th St': ([41.791478, -87.599861]
[41.78509714636, -87.6010727606]), 'Ellis Ave & 60th St to University Ave & 5
St': ([41.78509714636, -87.6010727606], [41.791478, -87.599861]), 'Ellis Ave
60th St to Ellis Ave & 55th St': ([41.78509714636, -87.6010727606],
[41.79430062054, -87.6014497734]), 'Calumet Ave & 33rd St to State St & 33rd
([41.834846139, -87.617929697], [41.834734, -87.625813]), 'Ellis Ave & 55th S
Ellis Ave & 60th St': ([41.79430062054, -87.6014497734], [41.78509714636,
-87.6010727606]), 'State St & 33rd St to Calumet Ave & 33rd St': ([41.834734,
-87.625813], [41.8349, -87.61793]), 'Loomis St & Lexington St to Morgan St &
St': ([41.87222873224032, -87.66136385500431], [41.871737, -87.65103]), 'Stat
& Chicago Ave to State St & Chicago Ave': ([41.8963355, -87.628603],
[41.89661720040753, -87.62857854366302]), 'Morgan St & Polk St to Loomis St &
Lexington St': ([41.87198333333333, -87.65116716666667], [41.87222873224032,
-87.66136385500431]), 'MLK Jr Dr & 29th St to State St & 33rd St': ([41.84206
-87.616927981], [41.834734, -87.625813])}
                                                       :
 {'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': ([41.892271399,
-87.612205386], [41.892278, -87.612043]), 'DuSable Lake Shore Dr & Monroe St
DuSable Lake Shore Dr & Monroe St': ([41.880958, -87.616743], [41.880958,
-87.616743]), 'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave':
([41.880958, -87.616743], [41.892278, -87.612043]), 'Shedd Aquarium to DuSabl
Lake Shore Dr & Monroe St': ([41.86722595682, -87.6153553902], [41.880958,
-87.616743]), 'Millennium Park to Millennium Park': ([41.8810317, -87.6240843
[41.8810317, -87.62408432]), 'W Washington Blvd & N Peoria St to W Washington
& N Peoria St': ([41.88, -87.65], [41.88, -87.65]), 'Shedd Aquarium to Shedd
Aquarium': ([41.86722595682, -87.6153553902], [41.86722595682, -87.6153553902
'Shedd Aquarium to Streeter Dr & Grand Ave': ([41.86722595682, -87.6153553902
[41.892278, -87.612043]), 'DuSable Lake Shore Dr & Monroe St to Shedd Aquariu
([41.880958, -87.616743], [41.86722595682, -87.6153553902]), 'University Ave
57th St to Ellis Ave & 60th St': ([41.791478, -87.599861], [41.78509714636,
-87.6010727606])}
```

```
In [42]: import folium

         #
         member_route_coords = {
             'Ellis Ave & 60th St to University Ave & 57th St': ([41.7850941666666
             'Ellis Ave & 60th St to Ellis Ave & 55th St': ([41.78509416666667, -8
             'University Ave & 57th St to Ellis Ave & 60th St': ([41.791512, -87.5
             'Ellis Ave & 55th St to Ellis Ave & 60th St': ([41.79430062054, -87.6
             'State St & 33rd St to Calumet Ave & 33rd St': ([41.834722281, -87.62
              'Calumet Ave & 33rd St to State St & 33rd St': ([41.834852815, -87.6
             'Loomis St & Lexington St to Morgan St & Polk St': ([41.8722287322403
             'Morgan St & Polk St to Loomis St & Lexington St': ([41.872038484, -8
             'University Ave & 57th St to Kimbark Ave & 53rd St': ([41.791512, -87
             'Ellis Ave & 58th St to Ellis Ave & 60th St': ([41.78856366666667, -8
         }

         #
         casual_route_coords = {
             'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': ([41.892278, -8
             'Ellis Ave & 60th St to Ellis Ave & 55th St': ([41.78509416666667, -8
             'DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe
             'Ellis Ave & 55th St to Ellis Ave & 60th St': ([41.79430062054, -87.6
             'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave': ([41.
             'Ellis Ave & 60th St to University Ave & 57th St': ([41.7850941666666
             'University Ave & 57th St to Ellis Ave & 60th St': ([41.791512, -87.5
             'University Ave & 57th St to Kimbark Ave & 53rd St': ([41.791512, -87
             'Streeter Dr & Grand Ave to Millennium Park': ([41.892278, -87.612043
             'Sheffield Ave & Fullerton Ave to Greenview Ave & Fullerton Ave': ([4
         }

         #
         m = folium.Map(location=[41.8781, -87.6298], zoom_start=12)

         #
         for route, coords in member_route_coords.items():
             folium.PolyLine(coords, color="blue").add_to(m)

         #
         for route, coords in casual_route_coords.items():
             folium.PolyLine(coords, color="red").add_to(m)

         #
         m.save("map.html")
```

```
In [43]: import folium

         #
         casual_route_coords = {
             'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': ([41.892278, -87
             'Ellis Ave & 60th St to Ellis Ave & 55th St': ([41.78509416666667, -87
             'DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe S
             'Ellis Ave & 55th St to Ellis Ave & 60th St': ([41.79430062054, -87.60
             'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave': ([41.8
             'Ellis Ave & 60th St to University Ave & 57th St': ([41.78509416666667
             'University Ave & 57th St to Ellis Ave & 60th St': ([41.791512, -87.59
             'University Ave & 57th St to Kimbark Ave & 53rd St': ([41.791512, -87
             'Streeter Dr & Grand Ave to Millennium Park': ([41.892278, -87.612043
             'Sheffield Ave & Fullerton Ave to Greenview Ave & Fullerton Ave': ([41
         }

         #
         route_usage = {
             'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': 192,
             'Ellis Ave & 60th St to Ellis Ave & 55th St': 180,
             'DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe S
             'Ellis Ave & 55th St to Ellis Ave & 60th St': 161,
             'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave': 155,
             'Ellis Ave & 60th St to University Ave & 57th St': 153,
             'University Ave & 57th St to Ellis Ave & 60th St': 133,
             'University Ave & 57th St to Kimbark Ave & 53rd St': 94,
             'Streeter Dr & Grand Ave to Millennium Park': 86,
             'Sheffield Ave & Fullerton Ave to Greenview Ave & Fullerton Ave': 81
         }

         #
         m = folium.Map(location=[41.8781, -87.6298], zoom_start=12)

         #
         for route, coords in casual_route_coords.items():
             #                        (                                 )
             line_weight = route_usage.get(route, 1) * 0.05  #

             #
             folium.PolyLine(coords, color="red", weight=line_weight,alpha=0.5).add

             #                       가
             folium.Marker(coords[1], popup=route).add_to(m)

         #
         m.save("map.html")

In [44]: # 'start_station_id'     'end_station_id'
         unique_stations = pd.concat([data['start_station_id'], data['end_station_i
         number_of_stations = len(unique_stations)

         #
         print(f"                  {number_of_stations}")    :
                                                  : 994
```

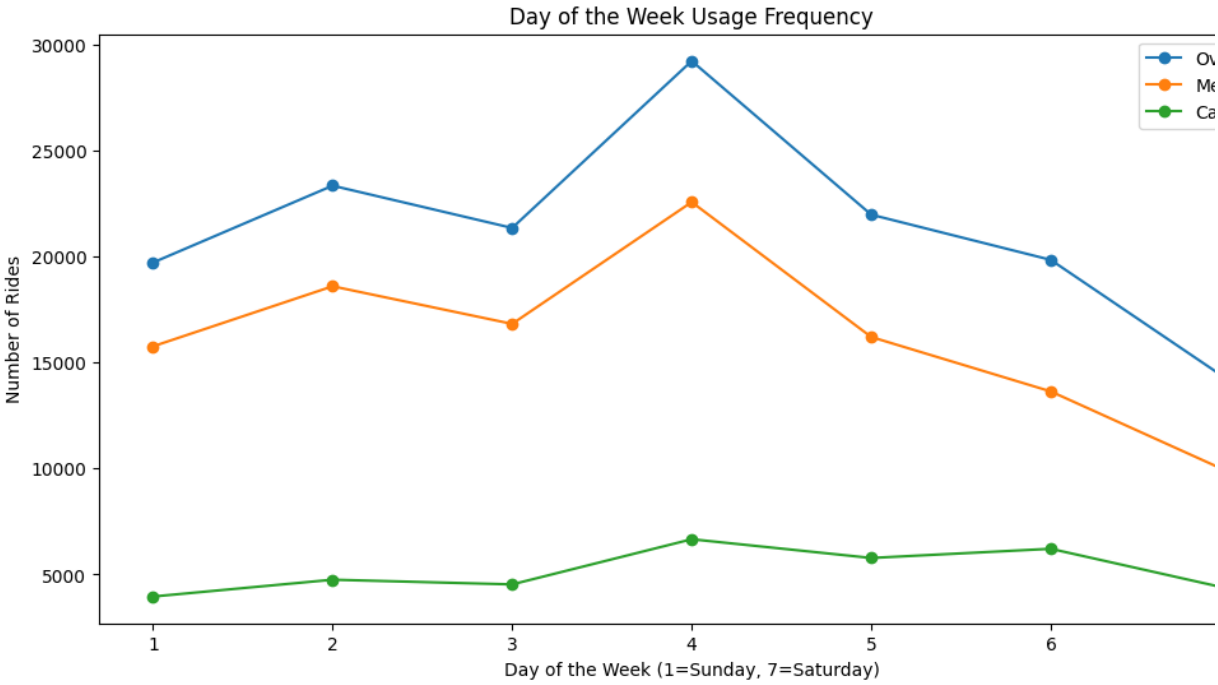
In [45]:
```
import folium


#
station_usage_start = data['start_station_id'].value_counts()
station_usage_end = data['end_station_id'].value_counts()
station_usage = station_usage_start.add(station_usage_end, fill_value=0)

#
station_locations = data.groupby('start_station_id').first()[['start_lat'

#
m = folium.Map(location=[station_locations['start_lat'].mean(), station_lo

#              가
for station_id, row in station_locations.iterrows():
    usage = station_usage.get(station_id, 0)
    #
    radius = min(usage, 1000) * 2  #          1000
    folium.Circle(
        location=(row['start_lat'], row['start_lng']),
        radius=radius,
        color='blue',
        fill=True,
        fill_opacity=0.01,
        weight=0.1
    ).add_to(m)

#
m.save("map.html")
```

In [46]:
```
#       가              (1 =       , 7 =
data['day_of_week'] = data['started_at'].dt.dayofweek + 1

#
overall_day_frequency = data['day_of_week'].value_counts().sort_index()

#
member_day_frequency = data[data['member_casual'] == 'member']['day_of_we
casual_day_frequency = data[data['member_casual'] == 'casual']['day_of_we

#
print("      {0}".format(overall_day_frequency)),
print("      {0}".format(member_day_frequency)),
print("       {0}".format(casual_day_frequency))
```

```
                          :  1    19730
2    23361
3    21363
4    29249
5    21991
6    19855
7    14116
Name: day_of_week, dtype: int64
                          :  1    15773
2    18609
3    16833
4    22586
5    16213
6    13643
7     9808
Name: day_of_week, dtype: int64
                             :  1    3957
2    4752
3    4530
4    6663
5    5778
6    6212
7    4308
Name: day_of_week, dtype: int64
```

In [47]:

```python
import matplotlib.pyplot as plt

#
overall_day_frequency = data['day_of_week'].value_counts().sort_index()

#
member_day_frequency = data[data['member_casual'] == 'member']['day_of_wee
casual_day_frequency = data[data['member_casual'] == 'casual']['day_of_wee

#
plt.figure(figsize=(12, 6))
plt.plot(overall_day_frequency.index, overall_day_frequency.values, label=
plt.plot(member_day_frequency.index, member_day_frequency.values, label='M
plt.plot(casual_day_frequency.index, casual_day_frequency.values, label='C

#
plt.title('Day of the Week Usage Frequency')
plt.xlabel('Day of the Week (1=Sunday, 7=Saturday)')
plt.ylabel('Number of Rides')
plt.xticks(range(1, 8))
plt.legend()

#
plt.show()
```



```
In [48]: #
         data['day_of_week'] = data['started_at'].dt.day_name()

         #                 가                            가
         best_marketing_times = data.groupby('day_of_week')['started_at'].apply(lam

         #
         print("           가         )                            :"
         for index, row in best_marketing_times.iterrows():
             print(f"{row['day_of_week']}: {row['started_at']}   ) "
```

```
            가                                    :
Friday: 17
Monday: 17
Saturday: 15
Sunday: 15
Thursday: 17
Tuesday: 17
Wednesday: 17
```

```
In [49]: #
         usage_by_day_hour = data.groupby(['day_of_week', 'hour_of_day']).size().re

         #        10
         top_10_times = usage_by_day_hour.nlargest(10, '      )       '

         #
         print("        10               )                              :"
         for index, row in top_10_times.iterrows():
             print(f"{row['day_of_week']} {row['hour_of_day']}    -    {row['    :
```

```
        10                                              :
Tuesday 17     -              : 2702
Thursday 17     -              : 2701
Thursday 8     -              : 2558
Thursday 16     -              : 2492
Monday 17     -              : 2306
Tuesday 16     -              : 2275
Wednesday 17     -              : 2220
Tuesday 8     -              : 2164
Thursday 7     -              : 2144
Wednesday 16     -              : 2144
```

```
In [50]: #
         casual_data = data[data['member_casual'] == 'casual']

         #
         usage_by_day_hour = casual_data.groupby(['day_of_week', 'hour_of_day']).s

         #         10
         top_10_times = usage_by_day_hour.nlargest(10, '     )       '

         #
         print("                             10)
         for index, row in top_10_times.iterrows():
             print(f"{row['day_of_week']} {row['hour_of_day']}     -     {row['    :
```

```
                             10                                              :
Thursday 17     -              : 579
Thursday 16     -              : 564
Sunday 15     -              : 561
Saturday 15     -              : 541
Thursday 15     -              : 528
Tuesday 17     -              : 494
Saturday 12     -              : 489
Saturday 16     -              : 485
Thursday 18     -              : 484
Friday 15     -              : 480
```

```
In [51]: import folium

         #
         stations = [
             'Shedd Aquarium',
             'Streeter Dr & Grand Ave',
             'Millennium Park',
             'DuSable Lake Shore Dr & Monroe St',
             'Kingsbury St & Kinzie St',
             'Clark St & Newport St',
             'LaSalle St & Illinois St',
             'Clark St & Elm St',
             'Wabash Ave & Grand Ave',
             'Michigan Ave & 8th St'
         ]

         #                                  (                  가
         station_frequencies = {
             'Shedd Aquarium': 433,
             'Streeter Dr & Grand Ave': 406,
             'Millennium Park': 300,
             'DuSable Lake Shore Dr & Monroe St': 298,
             'Kingsbury St & Kinzie St': 246,
             'Clark St & Newport St': 242,
             'LaSalle St & Illinois St': 236,
             'Clark St & Elm St': 231,
             'Wabash Ave & Grand Ave': 231,
             'Michigan Ave & 8th St': 227
         }

         #                                                  (가                )
         station_coordinates = {
             'Shedd Aquarium': {'start_lat': 41.867226, 'start_lng': -87.615355},
             'Streeter Dr & Grand Ave': {'start_lat': 41.892278, 'start_lng': -87.
             'Millennium Park': {'start_lat': 41.881032, 'start_lng': -87.624084},
             'DuSable Lake Shore Dr & Monroe St': {'start_lat': 41.880958, 'start_
             'Kingsbury St & Kinzie St': {'start_lat': 41.889177, 'start_lng': -87
             'Clark St & Newport St': {'start_lat': 41.944540, 'start_lng': -87.65
             'LaSalle St & Illinois St': {'start_lat': 41.890755, 'start_lng': -87
             'Clark St & Elm St': {'start_lat': 41.902973, 'start_lng': -87.631280
             'Wabash Ave & Grand Ave': {'start_lat': 41.891738, 'start_lng': -87.6
             'Michigan Ave & 8th St': {'start_lat': 41.872773, 'start_lng': -87.62
         }

         #
         map = folium.Map(location=[41.8781, -87.6298], zoom_start=13)

         #                                             가
         for station, freq in station_frequencies.items():
             coords = station_coordinates[station]
             folium.Circle(
                 location=[coords['start_lat'], coords['start_lng']],
                 radius=freq/2,  #
                 color='blue',
                 fill=True,
                 fill_color='blue',
                 popup=f"{station}: {freq}    "
             ).add_to(map)

         #
```

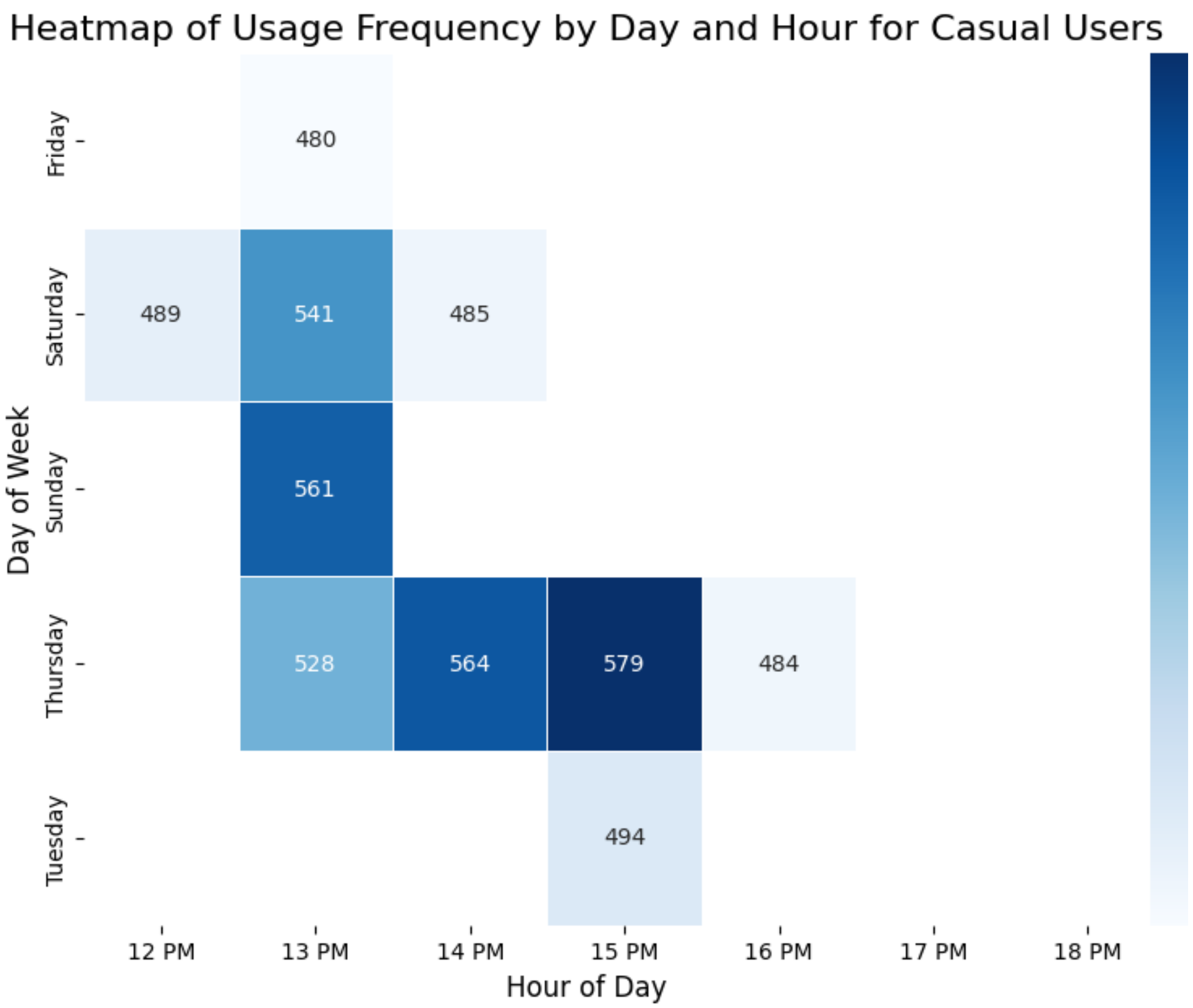
```
Out[51]: Make this Notebook Trusted to load map: File -> Trust Notebook
```

```
In [52]: #

         import folium

         #
         casual_route_coords = {
             'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': ([41.892278, -8
             'Ellis Ave & 60th St to Ellis Ave & 55th St': ([41.78509416666667, -8
             'DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe 
             'Ellis Ave & 55th St to Ellis Ave & 60th St': ([41.79430062054, -87.6
             'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave': ([41.
             'Ellis Ave & 60th St to University Ave & 57th St': ([41.785094166666
             'University Ave & 57th St to Ellis Ave & 60th St': ([41.791512, -87.5
             'University Ave & 57th St to Kimbark Ave & 53rd St': ([41.791512, -87
             'Streeter Dr & Grand Ave to Millennium Park': ([41.892278, -87.612043
             'Sheffield Ave & Fullerton Ave to Greenview Ave & Fullerton Ave': ([4
         }

         #
         route_usage = {
             'Streeter Dr & Grand Ave to Streeter Dr & Grand Ave': 192,
             'Ellis Ave & 60th St to Ellis Ave & 55th St': 180,
             'DuSable Lake Shore Dr & Monroe St to DuSable Lake Shore Dr & Monroe 
             'Ellis Ave & 55th St to Ellis Ave & 60th St': 161,
             'DuSable Lake Shore Dr & Monroe St to Streeter Dr & Grand Ave': 155,
             'Ellis Ave & 60th St to University Ave & 57th St': 153,
             'University Ave & 57th St to Ellis Ave & 60th St': 133,
             'University Ave & 57th St to Kimbark Ave & 53rd St': 94,
             'Streeter Dr & Grand Ave to Millennium Park': 86,
             'Sheffield Ave & Fullerton Ave to Greenview Ave & Fullerton Ave': 81
         }

         #
         m = folium.Map(location=[41.8781, -87.6298], zoom_start=12)

         #
         for route, coords in casual_route_coords.items():
             #                        (                                 )
             line_weight = route_usage.get(route, 1) * 0.05  #

             #
             folium.PolyLine(coords, color="blue", weight=line_weight, opacity=0.8

             #                                      가
             folium.Marker(coords[0], icon=folium.Icon(color='green'), popup=f"Sta
             folium.Marker(coords[1], icon=folium.Icon(color='red'), popup=f"End: 

         #
         m
```

Out[52]: Make this Notebook Trusted to load map: File -> Trust Notebook

In [53]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np

#
data = {
    'day_of_week': ['Thursday', 'Thursday', 'Sunday', 'Saturday', 'Thursda
    'hour_of_day': [17, 16, 15, 15, 15, 17, 12, 16, 18, 15],
    '      : [579, 564, 561, 541, 528, 494, 489, 485, 484, 480]
}
df = pd.DataFrame(data)

#
pivot_table = df.pivot("day_of_week", "hour_of_day", "     )       "

plt.figure(figsize=(10, 7))
sns.heatmap(pivot_table, annot=True, fmt=".0f", linewidths=.5, cmap="Blue

plt.title('Heatmap of Usage Frequency by Day and Hour for Casual Users', 
plt.ylabel('Day of Week', fontsize=12)

# x                  'PM'
hour_labels_pm = [f'{hour} PM' for hour in range(12, 19)]
plt.xticks(np.arange(0.5, len(hour_labels_pm) + 0.5), hour_labels_pm)

plt.xlabel('Hour of Day', fontsize=12)

plt.show()
```

```
<ipython-input-53-d0fc228e9f9c>:15: FutureWarning: In a future version of pan
all arguments of DataFrame.pivot will be keyword-only.
  pivot_table = df.pivot("day_of_week", "hour_of_day", "              ")
```


Heatmap of Usage Frequency by Day and Hour for Casual Users
Day of Week
Friday
Saturday
Sunday
Thursday
Tuesday
480
489
541
485
561
528
564
579
484
494
12 PM
13 PM
14 PM
15 PM
16 PM
17 PM
18 PM
Hour of Day