Lab Course Machine Learning Exercise Sheet 1

Python Warmup

Question 1

In [ ]:
```
import csv
import codecs
import urllib.request
from collections import Counter
import glob
import codecs
import re
import pandas as pd
import math
from cmath import exp
import matplotlib.pyplot as plt
import numpy as np
import nltk
from nltk.corpus import stopwords
import seaborn as sns
import warnings
warnings.filterwarnings("ignore")
from pandasql import sqldf
import pandas as pd
from sklearn import datasets
```

[2 points] In this part of the assignment, you have to write a word count program. Your program should read the provided text document on learnweb named random text.txt and then output the following stats:

In [ ]:
```
filepath = "/Users/farjad.ahmed/Documents/Studies/ML Lab/Exercise_01/random_text.txt"
with open(filepath) as f:
    sentences= f.readlines()
```

In [ ]:
```
# print(stopwords.words('english'))
```

In [ ]:
```
bigString = ''
for sent in sentences:
    bigString = bigString + sent

import string
bigString = bigString.translate(str.maketrans('', '', string.punctuation))
tokens = nltk.word_tokenize(bigString)
```

In [ ]:
```
stop_words = set(stopwords.words('english'))
word_tokens = nltk.word_tokenize(bigString)
sentence_filtered = [w for w in word_tokens if not w.lower() in stop_words]
sentence_filtered = []
for word in word_tokens:
    if word not in stop_words:
        sentence_filtered.append(word)
```

Part a

a) The number of unique non-stop words.(Hint: you can use "nltk" library to get a list of English language stop words.)

In [ ]:
```
len(sentence_filtered)
```

Out[ ]:
```
615
```

In [ ]:
```
# Finding the unique set of words that do not repeat
len(list(set(sentence_filtered)))
```

Out[ ]:
```
403
```

Part b

b) The top 5 most frequent non-stop words.

In [ ]:
```
from collections import Counter
myDict = Counter(sentence_filtered)
countList = list(myDict.items())
getList = sorted(countList, key=lambda x: x[1], reverse=True)
getList[:5]
```

Out[ ]: [('Harry', 26), ('Voldemort', 9), ('also', 8), ('He', 8), ('Dark', 7)]

Question 2

[2 points] In a sib1ple regression probleb1 we fit a straight line y = b1x + b to a given data. However, not all probleb1s in nature are by default linear. Given the data below see if a straight line is a good fit.

In cases where the data does not follow a linear trend, one can transforb1 the variables and then apply the linear regression technique to better fit the data. Frob1 the given choices, try which function would be a better representation for the data.

(a) Linear : y = b1x + b (b) Power : y = bxm (c) Exponential : y = bemx (d) Logarithmic : y = mlogx + b (e) Reciprocal : y = 1/(mx+b)

Generate a 2 x 2 subplot with the following techniques, plot, semilogx, semilogy, loglog. Read about these plotting techniques. These plots will let you understand which of the above 5 choices will be the best fit. Plot the data points and the best fit curve in a well-formatted plot with axis labels, title and the legend. (Hint: you can use the polyfit function from numpy for this part.)

Plotting all equations for all plotting methods. Answer: Power Estimates the data the best, it is evident from the working below.

In [ ]:
```
d = {'x': [0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0], 'y': [6.0, 4.83, 3.7, 3.15, 2.41, 1.83, 1.49, 1.21, 0.96, 0.
df = pd.DataFrame(data=d)
```

In [ ]:
```
plt.rcParams['figure.figsize'] = [15, 15]
```

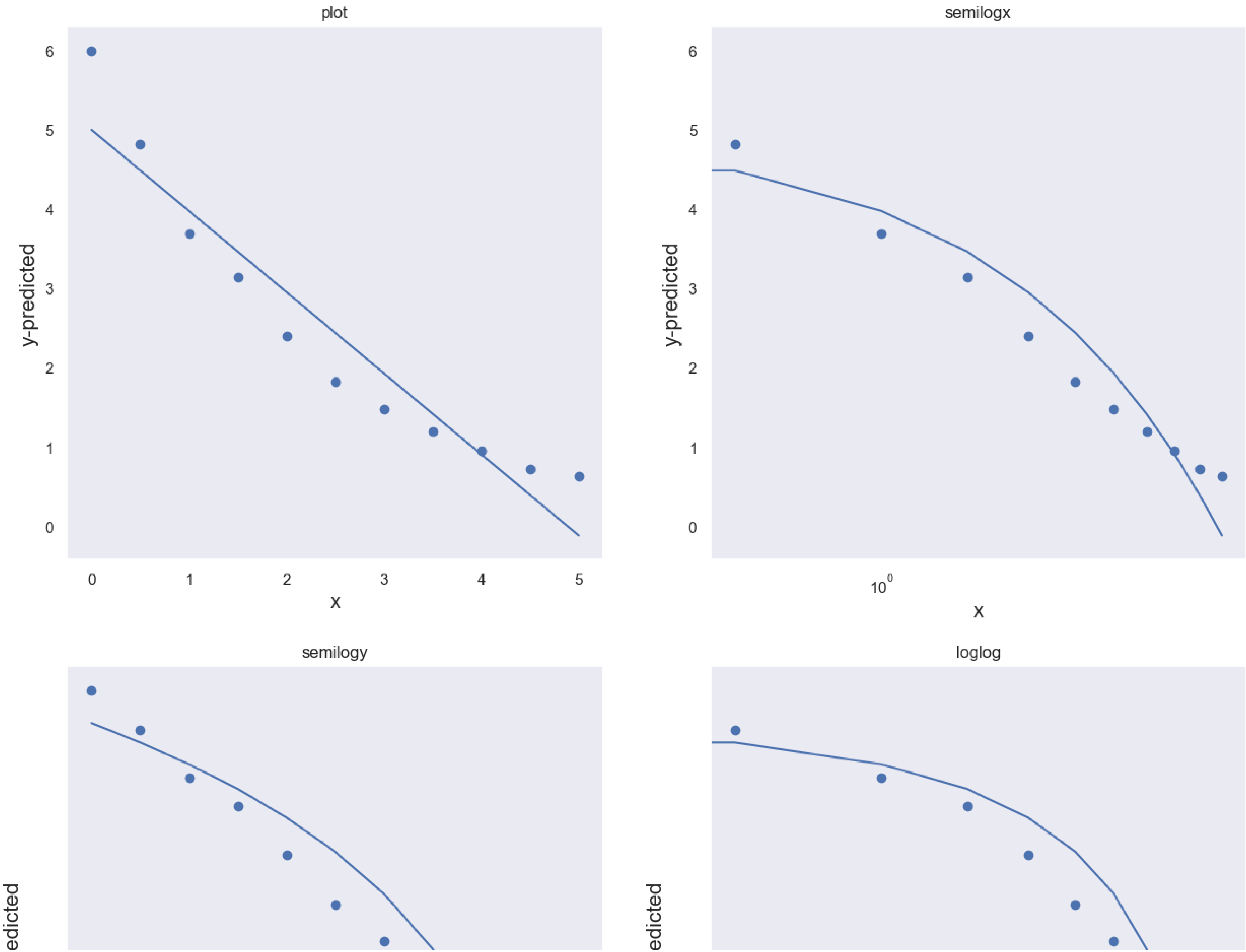
In [ ]:
```
x_2 = df['x'].to_numpy()
y_1 = df['y'].to_numpy()
xm = np.mean(x_2)
ym = np.mean(y_1)
b1 = np.sum((x_2-xm)*(y_1-ym))/(np.sum((x_2-xm)**2))
b0 = ym - b1*xm
print('b1: {} and b0: {}'.format(b1,b0))
```

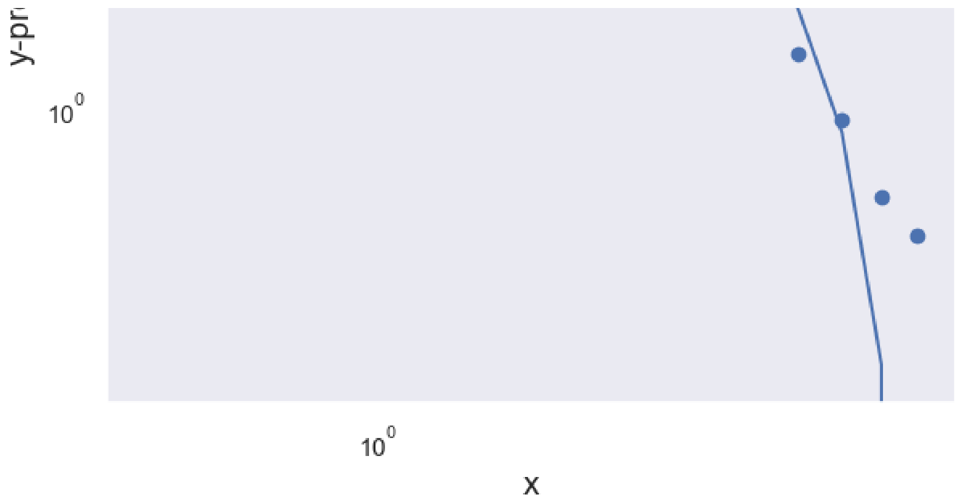
```
b1: -1.0221818181818 and b0: 5.005454545454546
```

In [ ]:
```
m = b1 #gradient
b = b0 #intercept
```

In [ ]:
```
x_2 = df['x']
Y = [m*x_2+b, b*pow(x_2,m), b*np.exp(x_2*m), m*np.log(x_2) + b, 1/(m*x_2 + b)]
```

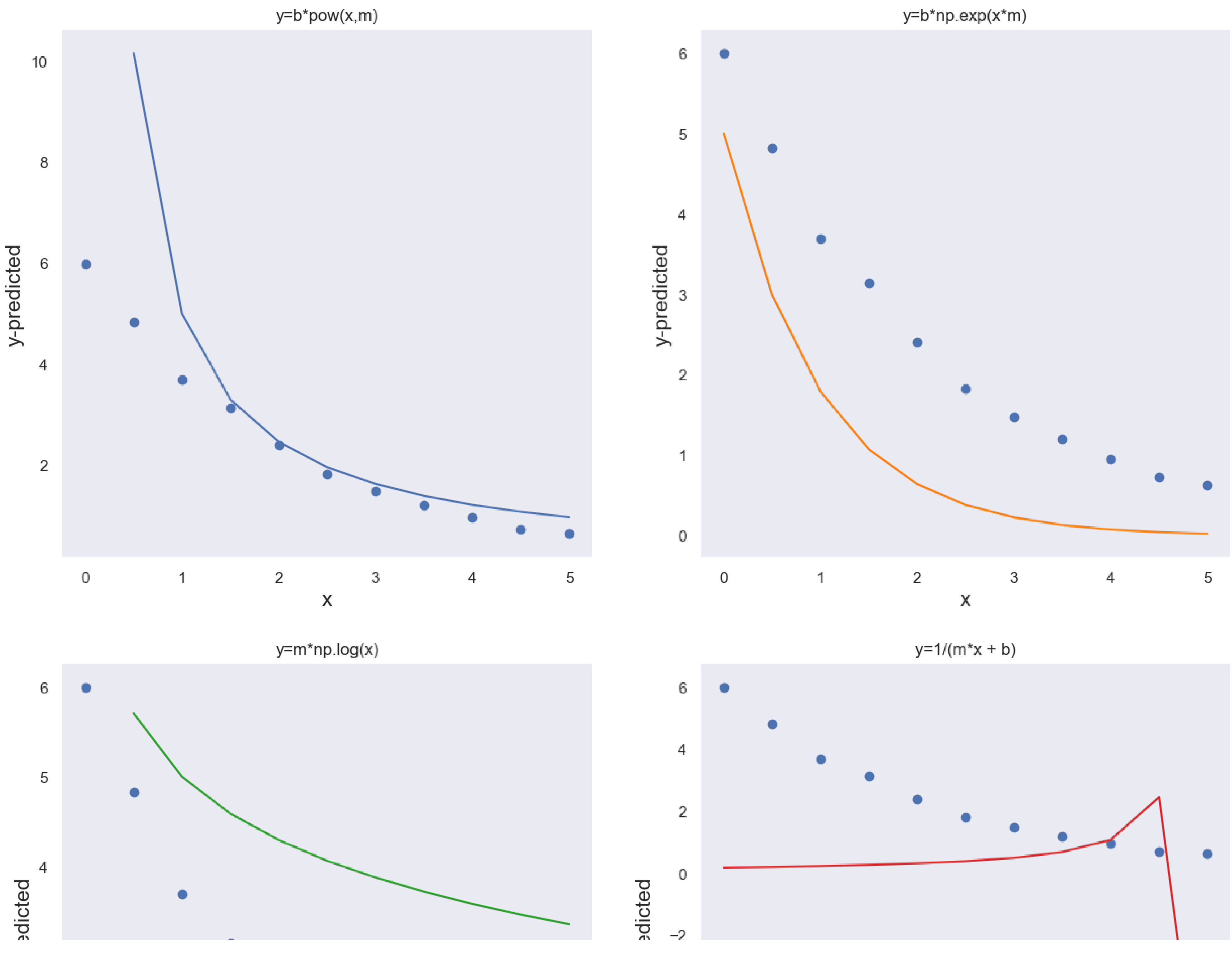
In [ ]:
```
fig = plt.figure()
x_2 = df['x']
y = Y[0]
plt.subplot(2,2,1)
plt.scatter(df['x'], df['y'], label='Original Data')
plt.plot(x_2, y, label='y=mx+c')
plt.title('plot')
plt.xlabel('x', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
plt.grid()

plt.subplot(2,2,2)
plt.scatter(df['x'], df['y'], label='Original Data')
plt.semilogx(x_2, y, label='y=mx+c')
plt.title('semilogx')
plt.xlabel('x', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
plt.grid()

plt.subplot(2,2,3)
plt.scatter(df['x'], df['y'], label='Original Data')
plt.semilogy(x_2, y, label='y=mx+c')
plt.title('semilogy')
plt.xlabel('x', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
plt.grid()

plt.subplot(2,2,4)
plt.scatter(df['x'], df['y'], label='Original Data')
plt.loglog(x_2, y, label='y=mx+c')
plt.title('loglog')
plt.xlabel('x', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
plt.grid()
plt.show()
```

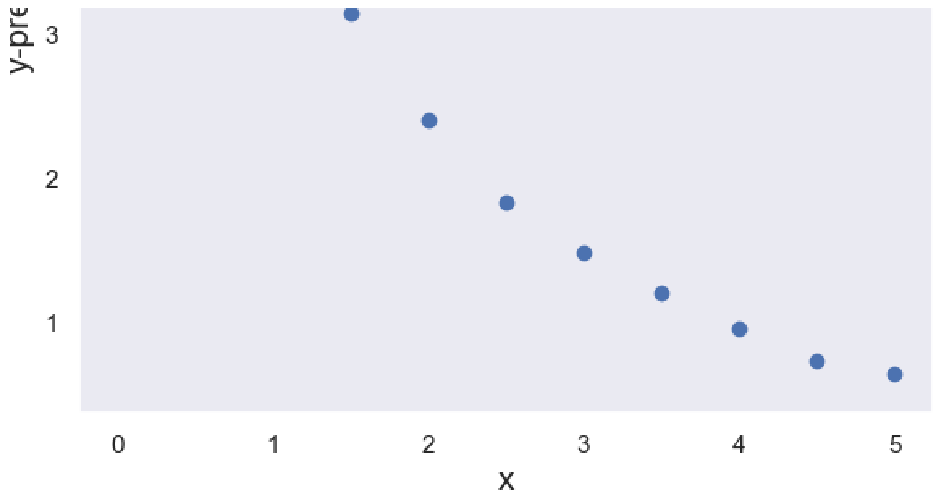

plot
semilogx
semilogy
loglog
y-predicted
x
0
1
2
3
4
5
6
10^0
edicted



Plot

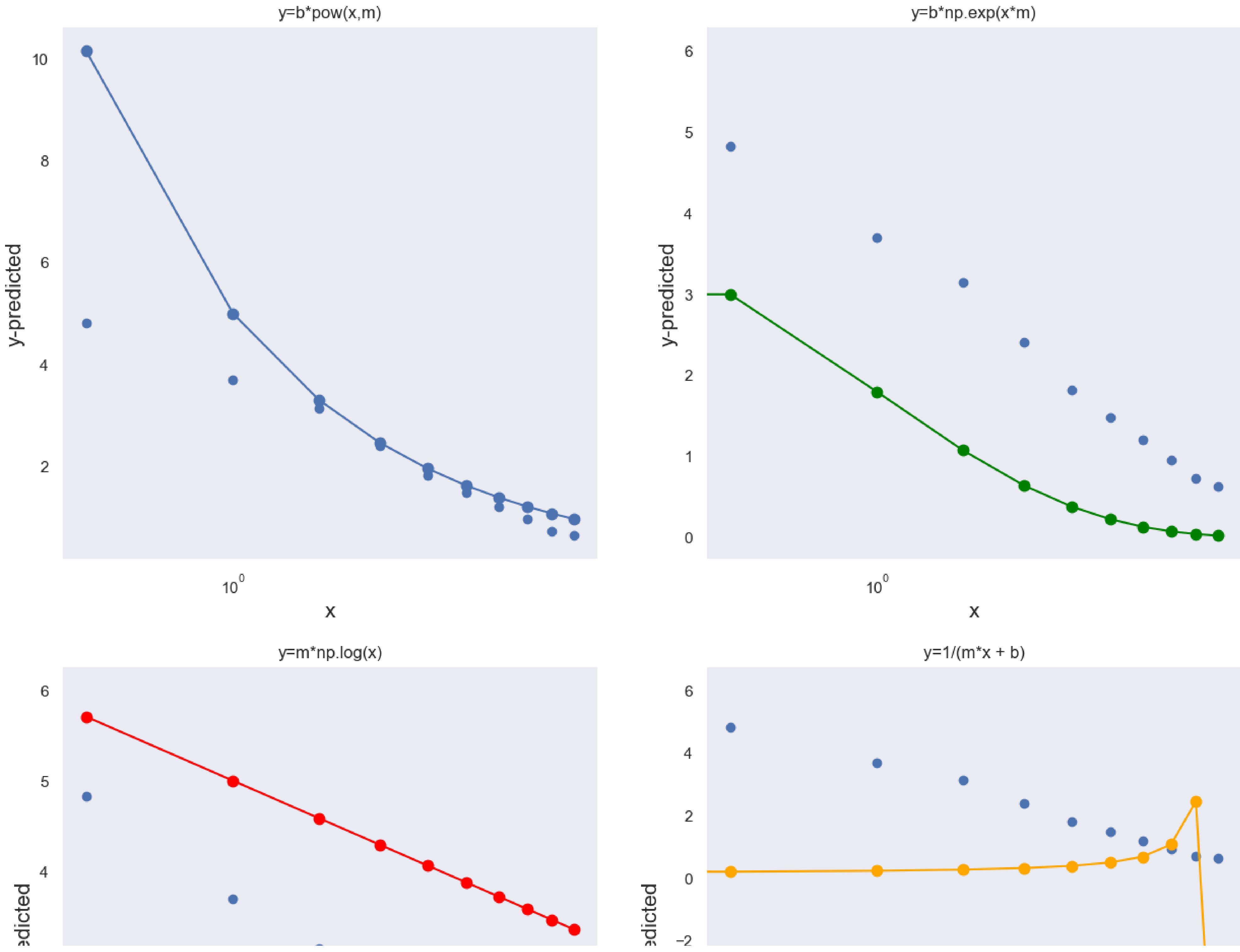
In [ ]:
```
fig_1, axs = plt.subplots(2, 2)
# plt.rcParams['figure.figsize'] = [15, 15]
axs[0, 0].plot(x_2, Y[1])
axs[0, 0].scatter(df['x'], df['y'])
axs[0, 0].set_title('y=b*pow(x,m)')

axs[0, 1].plot(x_2, Y[2], 'tab:orange')
axs[0, 1].set_title('y=b*np.exp(x*m)')
axs[0,1].scatter(df['x'], df['y'])

axs[1, 0].plot(x_2, Y[3], 'tab:green')
axs[1, 0].set_title('y=m*np.log(x)')
axs[1,0].scatter(df['x'], df['y'])

axs[1, 1].plot(x_2, Y[4], 'tab:red')
axs[1, 1].set_title('y=1/(m*x + b)')
axs[1,1].scatter(df['x'], df['y'])

for ax in axs.flat:
    ax.set_xlabel('x', fontsize=15)
    ax.set_ylabel('y-predicted', fontsize=15)
    ax.grid()
```


y=b*pow(x,m)
y=b*np.exp(x*m)
y=m*np.log(x)
y=1/(m*x + b)
y-predicted
x

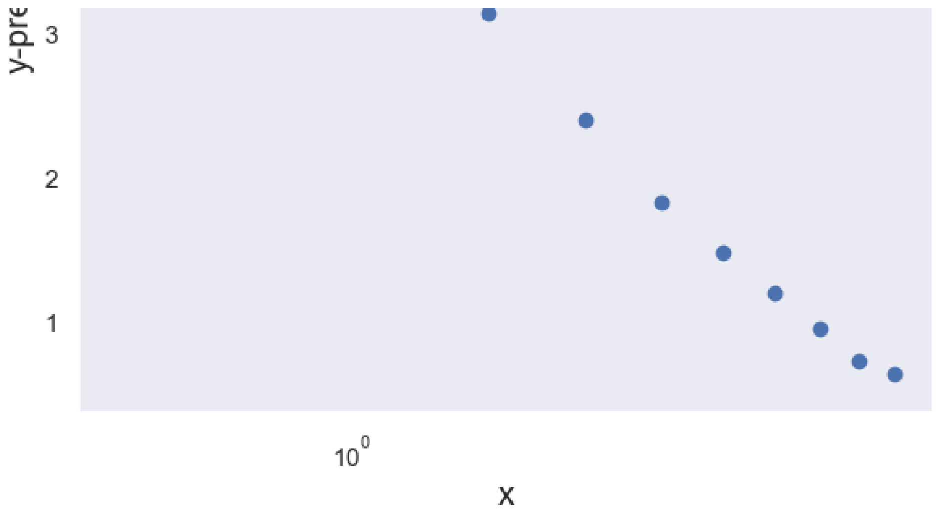


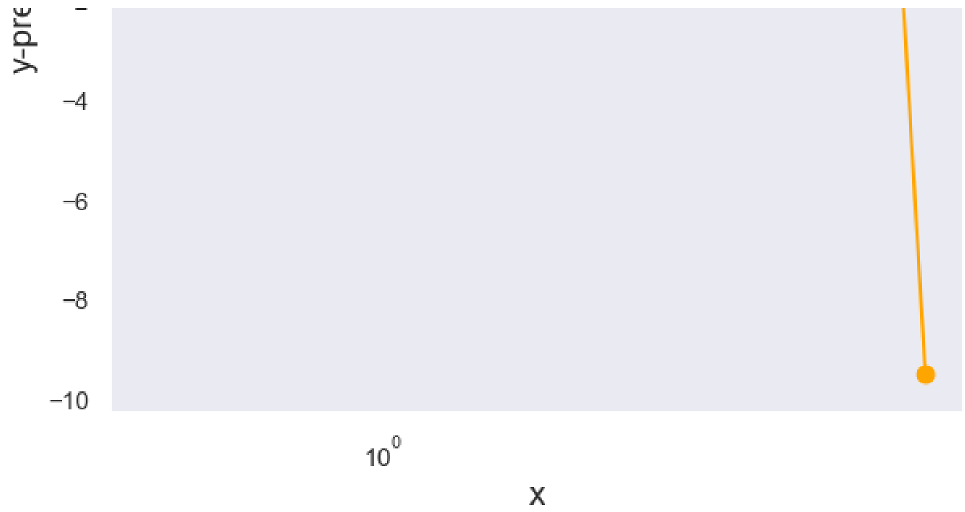
Semilogx

In [ ]:
```python
y =y_1
# plt.semilogx(x,y, marker='.', markersize=15, color='green')
fig_1, axs = plt.subplots(2, 2)
axs[0, 0].semilogx(x_2,Y[1], marker='.', markersize=15)
axs[0, 0].scatter(df['x'], df['y'])
axs[0, 0].set_title('y=b*pow(x,m)')

axs[0, 1].semilogx(x_2,Y[2], marker='.', markersize=15, color='green')
axs[0, 1].set_title('y=b*np.exp(x*m)')
axs[0,1].scatter(df['x'], df['y'])

axs[1, 0].semilogx(x_2,Y[3], marker='.', markersize=15, color='red')
axs[1, 0].set_title('y=m*np.log(x)')
axs[1,0].scatter(df['x'], df['y'])

axs[1, 1].semilogx(x_2,Y[4], marker='.', markersize=15, color='orange')
axs[1, 1].set_title('y=1/(m*x + b)')
axs[1,1].scatter(df['x'], df['y'])

for ax in axs.flat:
    ax.set_xlabel('x', fontsize=15)
    ax.set_ylabel('y-predicted', fontsize=15)
    ax.grid()
```



y=b*pow(x,m)
y=b*np.exp(x*m)
y=m*np.log(x)
y=1/(m*x + b)
y-predicted
x
10^0

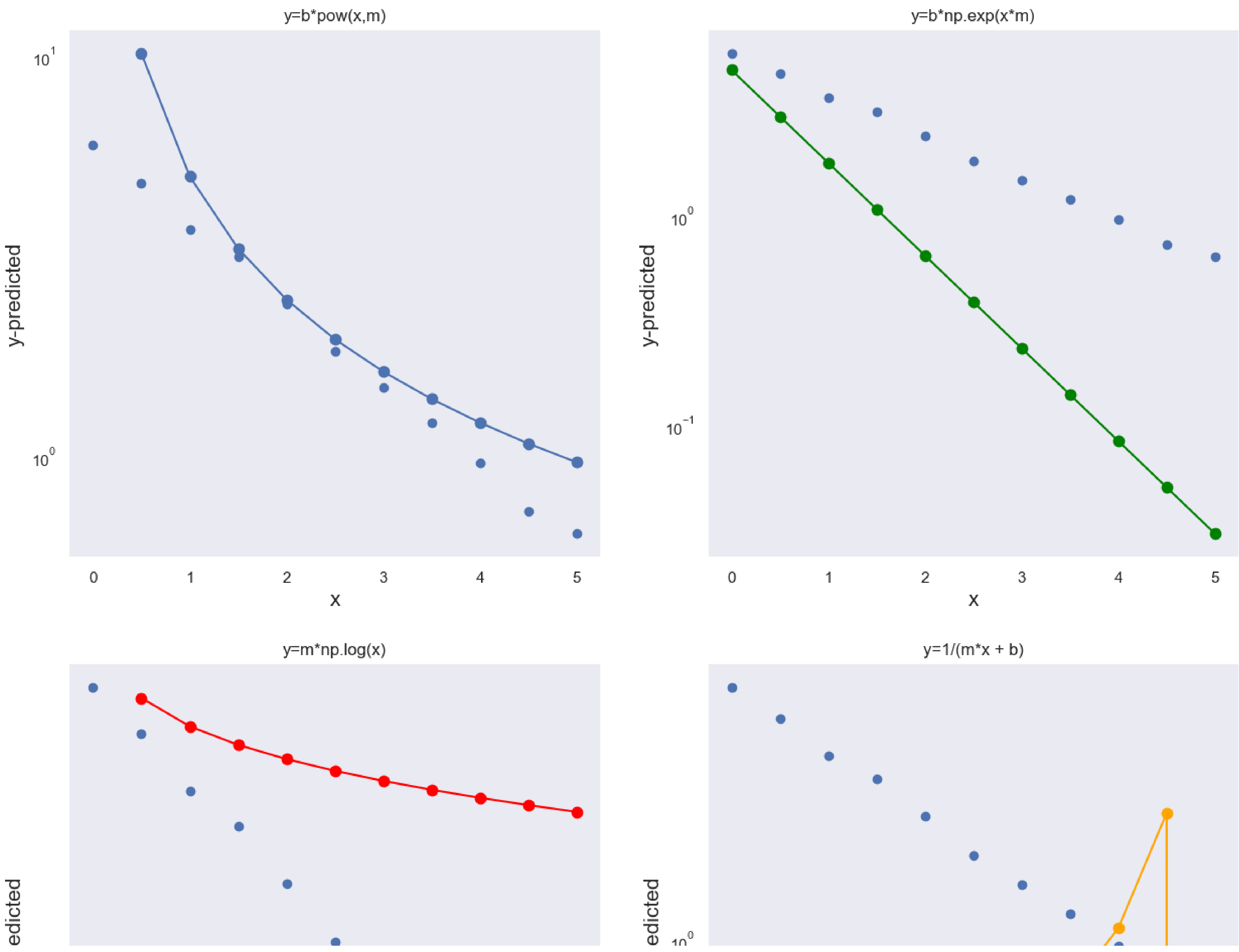




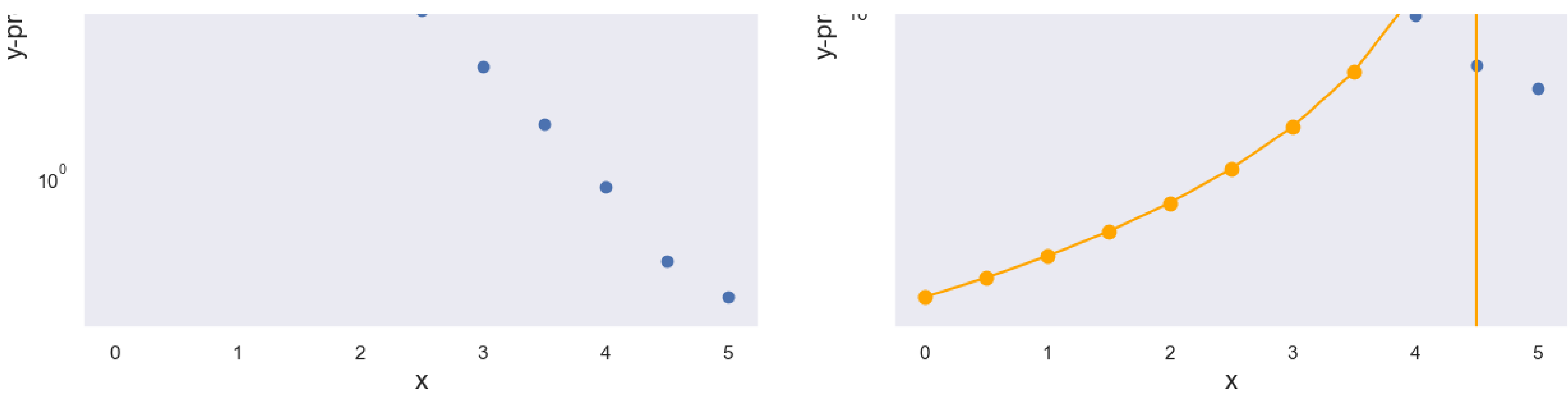
Semilogy

In [ ]:

```
y =y_1
# plt.semilogx(x,y, marker='.', markersize=15, color='green')
fig_1, axs = plt.subplots(2, 2)
# plt.rcParams['figure.figsize'] = [15, 15]
axs[0, 0].semilogy(x_2,Y[1], marker='.', markersize=15)
axs[0, 0].scatter(df['x'], df['y'])
axs[0, 0].set_title('y=b*pow(x,m)')

axs[0, 1].semilogy(x_2,Y[2], marker='.', markersize=15, color='green')
axs[0, 1].set_title('y=b*np.exp(x*m)')
axs[0,1].scatter(df['x'], df['y'])

axs[1, 0].semilogy(x_2,Y[3], marker='.', markersize=15, color='red')
axs[1, 0].set_title('y=m*np.log(x)')
axs[1,0].scatter(df['x'], df['y'])

axs[1, 1].semilogy(x_2,Y[4], marker='.', markersize=15, color='orange')
axs[1, 1].set_title('y=1/(m*x + b)')
axs[1,1].scatter(df['x'], df['y'])

for ax in axs.flat:
    ax.set_xlabel('x', fontsize=15)
    ax.set_ylabel('y-predicted', fontsize=15)
    ax.grid()
```



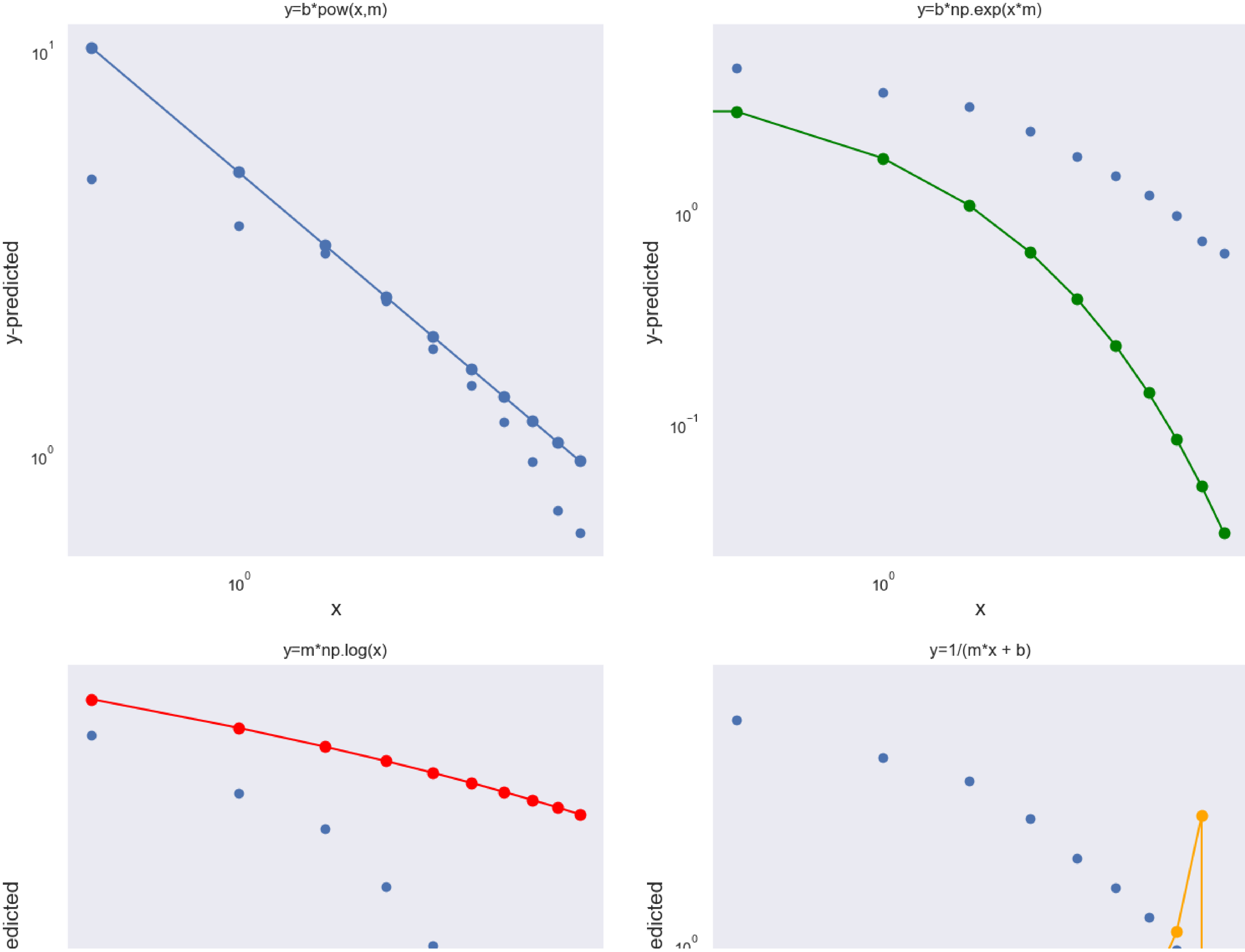
y=b*pow(x,m)
10^1
10^0
y-predicted
0
1
2
3
4
5
x
y=b*np.exp(x*m)
10^0
10^-1
y-predicted
0
1
2
3
4
5
x
y=m*np.log(x)
edicted
y=1/(m*x + b)
edicted
10^0

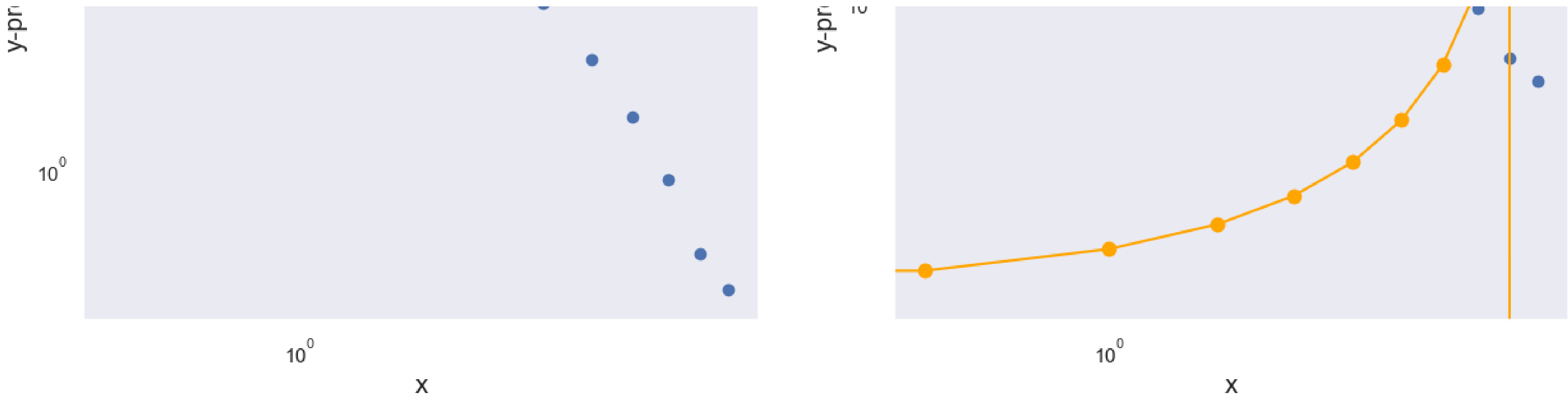


loglog

In [ ]:

```
y =y_1
# plt.semilogx(x,y, marker='.', markersize=15, color='green')
fig_1, axs = plt.subplots(2, 2)
axs[0, 0].loglog(x_2,Y[1], marker='.', markersize=15)
axs[0, 0].scatter(df['x'], df['y'])
axs[0, 0].set_title('y=b*pow(x,m)')

axs[0, 1].loglog(x_2,Y[2], marker='.', markersize=15, color='green')
axs[0, 1].set_title('y=b*np.exp(x*m)')
axs[0,1].scatter(df['x'], df['y'])

axs[1, 0].loglog(x_2,Y[3], marker='.', markersize=15, color='red')
axs[1, 0].set_title('y=m*np.log(x)')
axs[1,0].scatter(df['x'], df['y'])

axs[1, 1].loglog(x_2,Y[4], marker='.', markersize=15, color='orange')
axs[1, 1].set_title('y=1/(m*x + b)')
axs[1,1].scatter(df['x'], df['y'])

for ax in axs.flat:
    ax.set_xlabel('x', fontsize=15)
    ax.set_ylabel('y-predicted', fontsize=15)
    ax.grid()
```


y=b*pow(x,m)
10^1
10^0
y-predicted
10^0
x
y=b*np.exp(x*m)
10^0
10^-1
y-predicted
10^0
x
y=m*np.log(x)
edicted
y=1/(m*x + b)
edicted




```
In [ ]: plt.rcParams['figure.figsize'] = [5, 5]
```

Question 3

```
In [ ]: df_3 = {'x': [0.5, 2.4, 3.2, 4.9, 6.5, 7.8], 'y': [0.8, 9.3, 37.9, 68.2, 155.0, 198.0]}
        df_3 = pd.DataFrame(data=df_3)
        x_3 = df_3['x'].to_numpy()
        y_3 = df_3['y'].to_numpy()
```

```
In [ ]: plt.rcParams['figure.figsize'] = [8, 5]
```

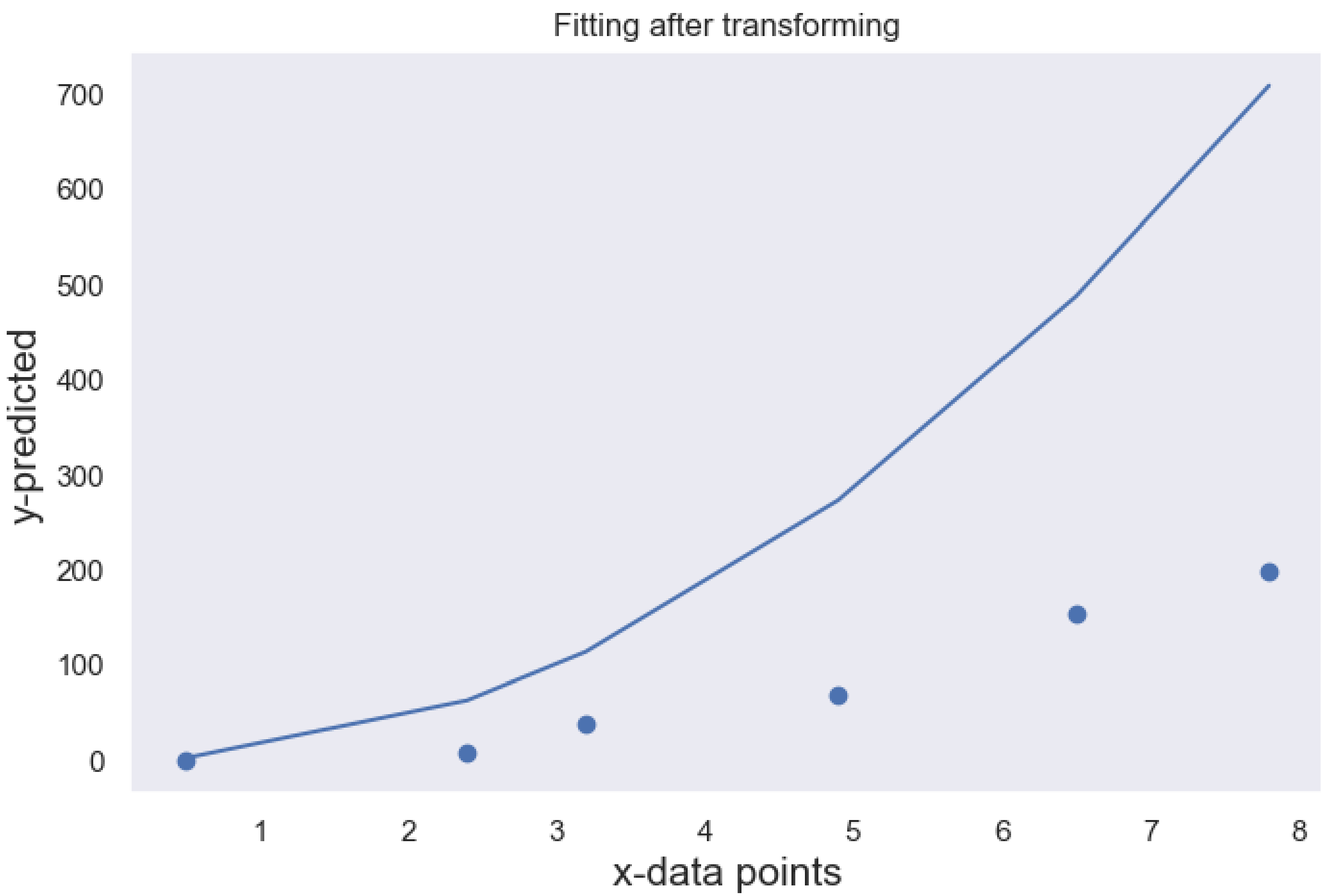
```
In [ ]: x_dash = np.log(x_3)
        y_dash = np.log(y_3)
```

```
In [ ]: def powerfit(x, y):
            xm = np.mean(x)
            ym = np.mean(y)
            b1 = np.sum((x-xm)*(y-ym))/(np.sum((x-xm)**2))
            b0 = ym - b1*xm
            return (b1, b0)
        b1, b0 = powerfit(x_dash, y_dash)
        m = b1 #gradient
        b = b0 #intercept
        print('m: {}, b:{}'.format(b1, b0))
```

```
m: 2.049553636875363, b:1.022453728075393
```

In [ ]:
```
b = pow(10,b)
```

In [ ]:
```
fig = plt.figure()
y_predicted = b*pow(x_3,m)
# print(y_3)
plt.scatter(df_3['x'], df_3['y'], label='Original Data')
plt.plot(x_3, y_predicted, label='y=b*x^m')
# plt.title('Graph of y=-1.022x+5.005 and Original Data Points', fontsize=15)
plt.xlabel('x-data points', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
# plt.legend(loc="upper right", prop={'size':13})
plt.title('Fitting after transforming')
plt.grid()
plt.show()
```

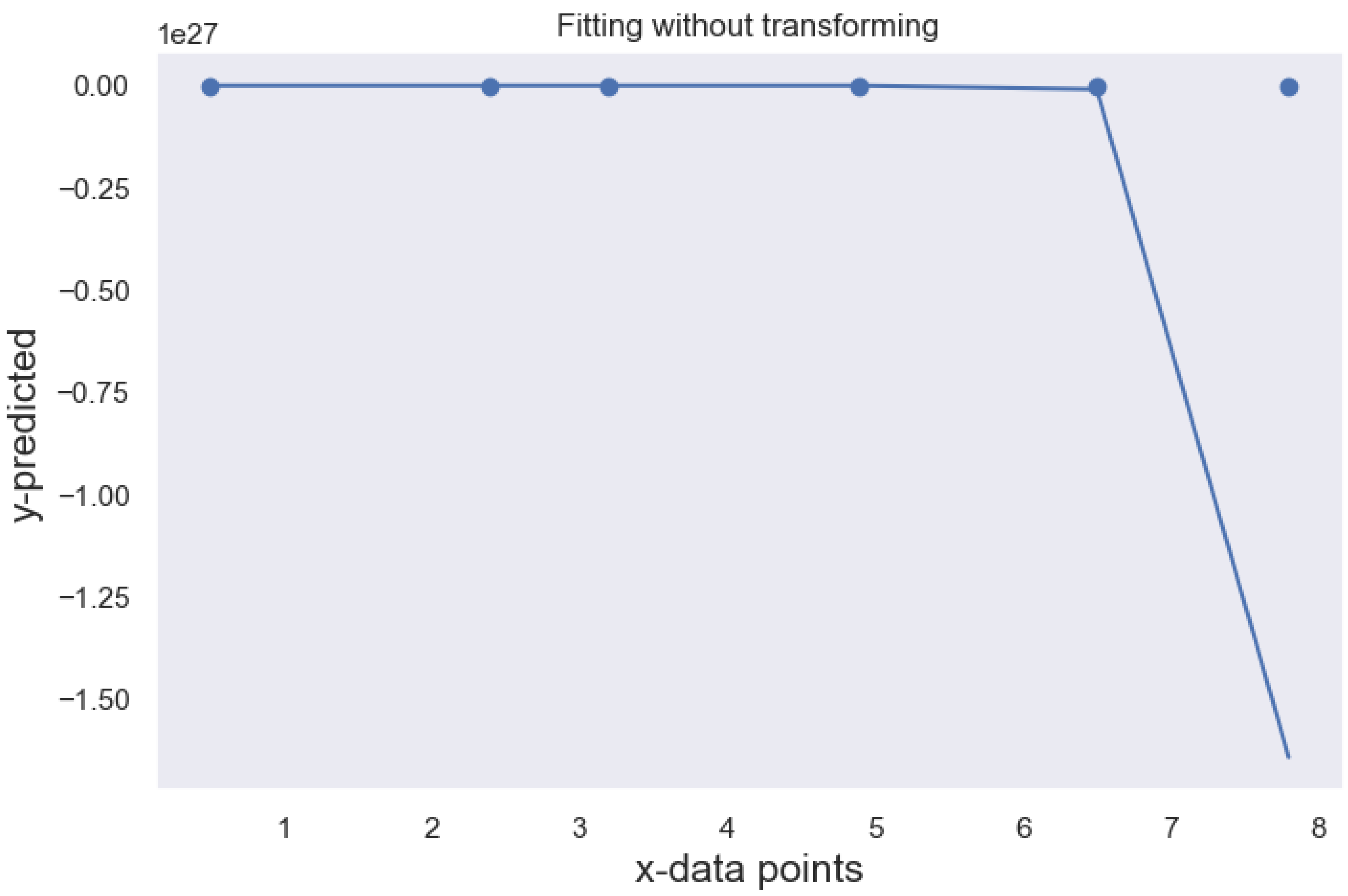


NOT TRANSFORMING

In [ ]:
```
def powerfit(x, y):
    xm = np.mean(x)
    ym = np.mean(y)
    b1 = np.sum((x-xm)*(y-ym))/(np.sum((x-xm)**2))
    b0 = ym - b1*xm
    return (b1, b0)
b1, b0 = powerfit(x_3, y_3)
m = b1 #gradient
b = b0 #intercept
print('m: {}, b:{}'.format(b1, b0))
```

```
m: 28.679241852643063, b:-42.73080314531158
```

In [ ]:
```
fig = plt.figure()
y_predicted = b*pow(x_3,m)
# print(y_3)
plt.scatter(df_3['x'], df_3['y'], label='Original Data')
plt.plot(x_3, y_predicted, label='y=b*x^m')
# plt.title('Graph of y=-1.022x+5.005 and Original Data Points', fontsize=15)
plt.xlabel('x-data points', fontsize=15)
plt.ylabel('y-predicted', fontsize=15)
# plt.legend(loc="upper right", prop={'size':13})
plt.title('Fitting without transforming')
plt.grid()
plt.show()
```

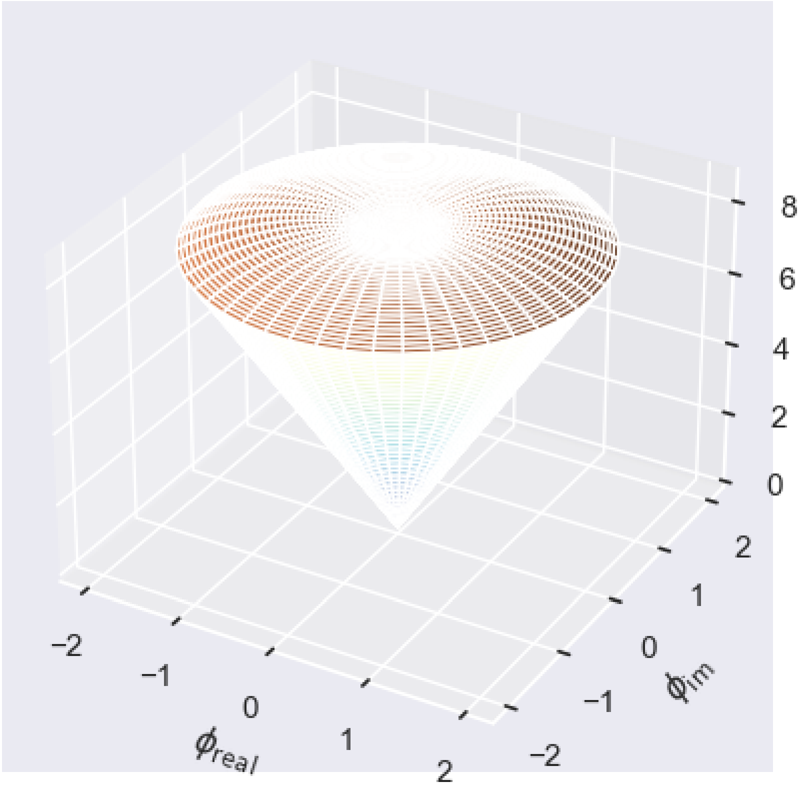


Question 4

In [ ]:

```
import matplotlib.pyplot as plt
import numpy as np

fig = plt.figure()
ax = fig.add_subplot(projection='3d')

# # # Create the mesh in polar coordinates and compute corresponding Z.
r = np.linspace(0, 2)
theta = np.linspace(0, 2*np.pi)

R, THETA = np.meshgrid(r, theta)
Z = 4*R
# Express the mesh in the cartesian system.
X = R*np.cos(THETA)
Y = R*np.sin(THETA)

# Plot the surface.
ax.plot_surface(X, Y, Z, cmap=plt.cm.YlGnBu_r)

# # #top of cone
theta_t = np.linspace(0,2*np.pi)
phi_t = np.linspace(0,np.pi/2)
# r_t = np.linspace(0,2)
PHI_t, THETA_t = np.meshgrid(phi_t, theta_t)
# PHI_t, _ = np.meshgrid(phi_t, theta_t)

# Make data.
X_t = R*np.cos(THETA_t)*np.sin(PHI_t)
Y_t = R*np.sin(THETA_t)*np.sin(PHI_t)
Z_t = 8+R*np.cos(PHI_t)

# Plot the surface.
surf = ax.plot_surface(X_t, Y_t, Z_t)

# ax.view_init(25, 20)

# Tweak the limits and add latex math labels.
# ax.set_zlim(0, 1)
ax.set_xlabel(r'$\phi_\mathrm{real}$')
ax.set_ylabel(r'$\phi_\mathrm{im}$')
ax.set_zlabel(r'$V(\phi)$')
```

```
plt.show()
```



Exploratory Analysis on Real-World Data

Question 2 - Part 1

Load the dataset using pandas and display all necessary information contained in the file

In [ ]:
```
pd.set_option('display.max_rows', None)
```

In [ ]:
```
dframe = pd.read_csv("/Users/farjad.ahmed/Documents/Studies/ML Lab/Exercise_01/task1.txt")
```

In [ ]:
```
dframe.columns
```

Out[ ]:
```
Index(['Year', 'Month', 'DayofMonth', 'DayOfWeek', 'DepTime', 'CRSDepTime',
       'ArrTime', 'CRSArrTime', 'UniqueCarrier', 'FlightNum', 'TailNum',
       'ActualElapsedTime', 'CRSElapsedTime', 'AirTime', 'ArrDelay',
       'DepDelay', 'Origin', 'Dest', 'Distance', 'TaxiIn', 'TaxiOut',
       'Cancelled', 'CancellationCode', 'Diverted', 'CarrierDelay',
       'WeatherDelay', 'NASDelay', 'SecurityDelay', 'LateAircraftDelay'],
      dtype='object')
```

In [ ]:
```
dframe.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99260 entries, 0 to 99259
Data columns (total 29 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   Year               99260 non-null  int64  
 1   Month              99260 non-null  int64  
 2   DayofMonth         99260 non-null  int64  
 3   DayOfWeek          99260 non-null  int64  
 4   DepTime            97847 non-null  float64
 5   CRSDepTime         99260 non-null  int64  
 6   ArrTime            97693 non-null  float64
 7   CRSArrTime         99260 non-null  int64  
 8   UniqueCarrier      99260 non-null  object 
 9   FlightNum          99260 non-null  int64  
 10  TailNum            98156 non-null  object 
 11  ActualElapsedTime  97659 non-null  float64
 12  CRSElapsedTime     99249 non-null  float64
 13  AirTime            97659 non-null  float64
 14  ArrDelay           97659 non-null  float64
 15  DepDelay           97847 non-null  float64
 16  Origin             99260 non-null  object 
 17  Dest               99260 non-null  object 
 18  Distance           99260 non-null  int64  
 19  TaxiIn             97693 non-null  float64
 20  TaxiOut            97841 non-null  float64
 21  Cancelled          99260 non-null  int64  
 22  CancellationCode   1420 non-null   object 
 23  Diverted           99260 non-null  int64  
 24  CarrierDelay       19747 non-null  float64
 25  WeatherDelay       19747 non-null  float64
 26  NASDelay           19747 non-null  float64
 27  SecurityDelay      19747 non-null  float64
 28  LateAircraftDelay  19747 non-null  float64
dtypes: float64(14), int64(10), object(5)
memory usage: 22.0+ MB
```

In [ ]:

```
dframe.head(10)
```

Out[ ]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	TaxiIn	TaxiOut	Cancelled	Canc
0	2008	1	1	2	120.0	1935	309.0	2130	9E	5746	...	3.0	18.0	0	
1	2008	1	1	2	555.0	600	826.0	835	AA	1614	...	7.0	11.0	0	
2	2008	1	1	2	600.0	600	728.0	729	YV	2883	...	7.0	16.0	0	
3	2008	1	1	2	601.0	605	727.0	750	9E	5743	...	4.0	12.0	0	
4	2008	1	1	2	601.0	600	654.0	700	AA	1157	...	5.0	10.0	0	
5	2008	1	1	2	636.0	645	934.0	932	NW	1674	...	11.0	22.0	0	
6	2008	1	1	2	646.0	655	735.0	750	CO	340	...	6.0	15.0	0	
7	2008	1	1	2	650.0	700	841.0	857	XE	541	...	6.0	11.0	0	
8	2008	1	1	2	650.0	650	1139.0	1145	AA	1182	...	4.0	12.0	0	
9	2008	1	1	2	654.0	700	1117.0	1133	B6	1060	...	13.0	13.0	0	

10 rows × 29 columns

Question 2 - part 2

You are tasked as a data scientist to create a story that is visually appealing from this data. Create plots using matplotlib/seaborn that will depict such interesting stories from flights that depart from and arrive in the Austin region. The figures should be annotated properly and also easily understandable on the first glance. A list of questions that can be explored/answered as reference are given below. Of course, you are free to explore any other possibilities.

Investigate what time of the day it is best to fly so as to have the least possible delays. Does this change with airlines?

In [ ]:
```
#Adding a column that holds total delays in a journey except the arrival delay, this is added to the dframe1 as 'total_delays'
dframe1 = dframe
# dframe1['total_delays'] = dframe1['DepDelay'] + dframe1['CarrierDelay'] + dframe1['WeatherDelay'] + dframe1['NASDelay'] + dfr
# # dframe1 = dframe1[dframe1.total_delays.notnull()]
# dframe1 = dframe1.dropna(subset=['CRSDepTime'])
```

In [ ]:
```
dframe1['avg_delays'] = dframe1[['DepDelay', 'CarrierDelay', 'WeatherDelay', 'NASDelay', 'SecurityDelay', 'LateAircraftDelay']]
# dframe1.head(50)
```

In [ ]:
```
#Converting single digit hour values in CRSDepTime to hhmm by padding a 0 at the beginning
dframe1['CRSDepTime'] = dframe1['CRSDepTime'].astype(int).astype(str)
```

```python
dframe1['CRSDepTime'] = dframe1['CRSDepTime'].str.zfill(4)
#Splitting the column to obtain hh (hours) values from the dataframe which will be used to group by the data.
#Minutes are ignored, hence the values will be accurate to hourly time periods
dframe1['DT_Hours'] = dframe1['CRSDepTime'].str.slice(0,2)
```

In [ ]:

```python
result1 = dframe1.groupby('DT_Hours', as_index=False)['avg_delays'].min()
result1
```

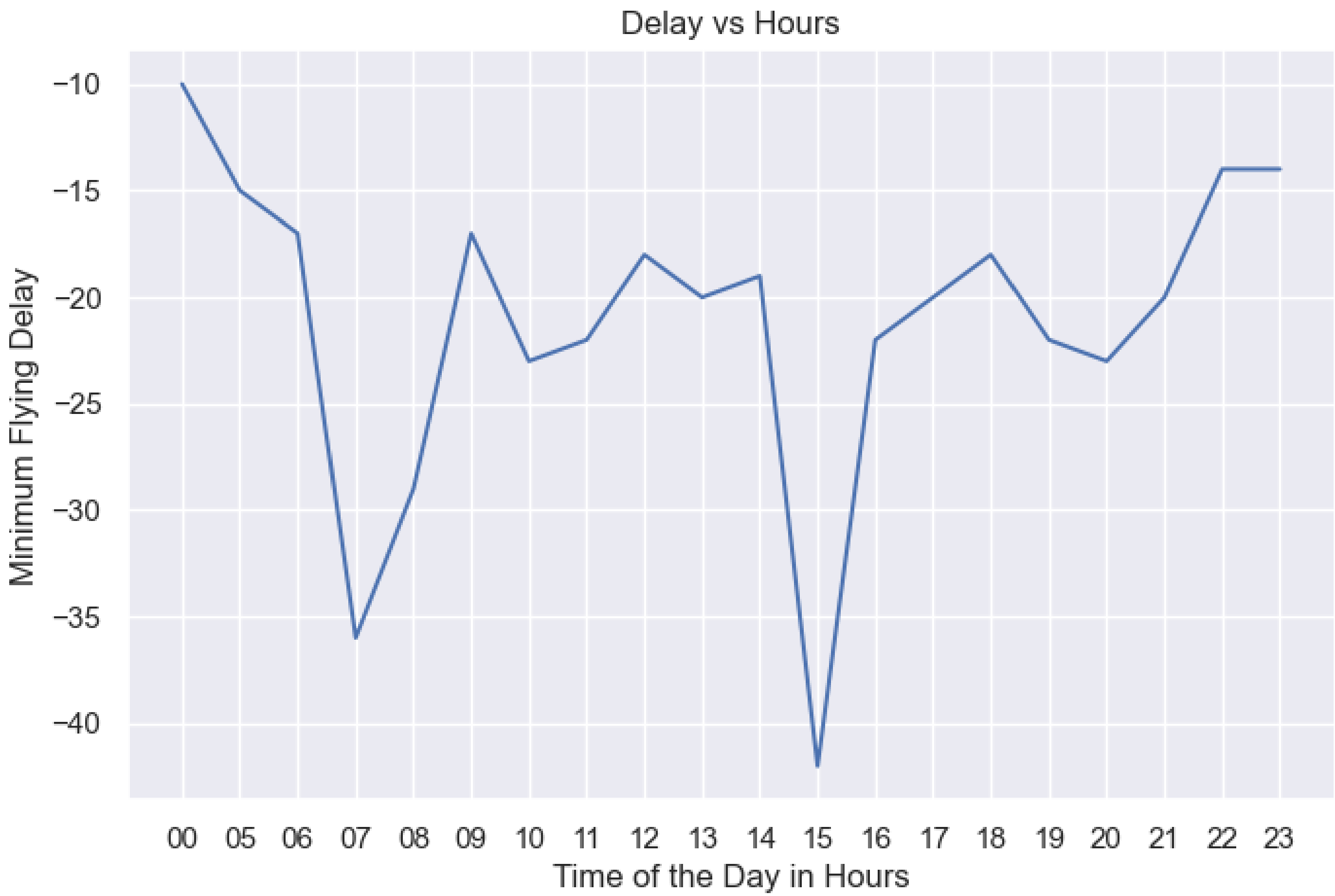
Out[ ]:

	DT_Hours	avg_delays
0	00	-10.0
1	05	-15.0
2	06	-17.0
3	07	-36.0
4	08	-29.0
5	09	-17.0
6	10	-23.0
7	11	-22.0
8	12	-18.0
9	13	-20.0
10	14	-19.0
11	15	-42.0
12	16	-22.0
13	17	-20.0
14	18	-18.0
15	19	-22.0
16	20	-23.0
17	21	-20.0
18	22	-14.0
19	23	-14.0

In [ ]:

```python
ax = sns.lineplot(result1, x=result1['DT_Hours'], y=result1['avg_delays'])
```

```
ax.set(xlabel='Time of the Day in Hours', ylabel='Minimum Flying Delay', title='Delay vs Hours')
plt.show()
```



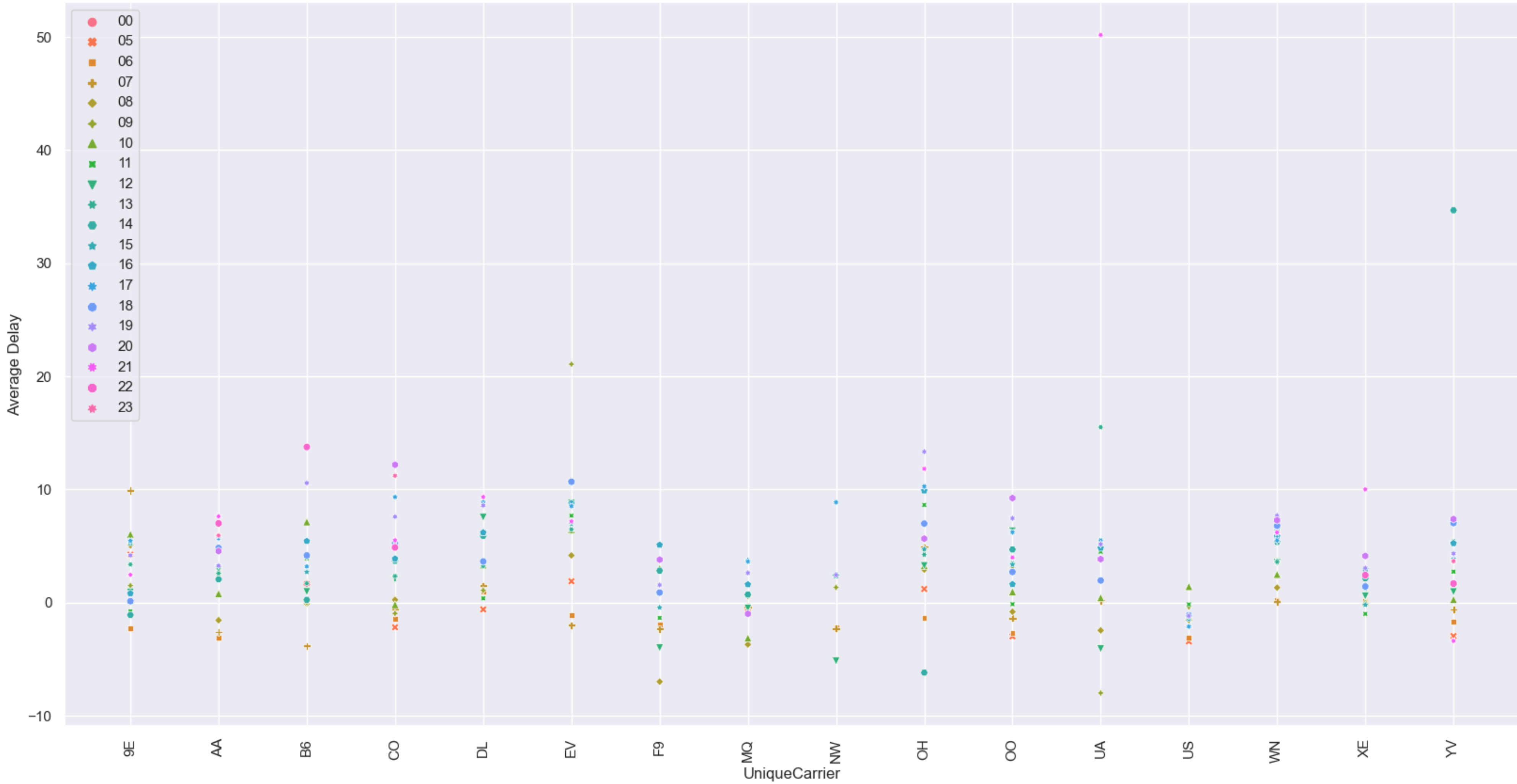
Investigating wether the flying delays vary with airlines

In [ ]:
```
result2 = dframe1.groupby(['DT_Hours', 'UniqueCarrier'], as_index=False)['avg_delays'].min()
# result2
```

In [ ]:
```
# #Tried doing this with sql for exploring purposes, hence some are done with pandas functions some with sql
# query = "Select DT_Hours, UniqueCarrier, min(avg_delays) as min_delays from dframe1 group by DT_Hours, UniqueCarrier"
# dframe2 = sqldf(query, globals())
# dframe2.head(50)
```

In [ ]:
```
fig, ax = plt.subplots(figsize=(20, 10))
```

```
sns.scatterplot(dframe1.groupby([dframe1['UniqueCarrier'], 'DT_Hours'])['avg_delays'].mean().unstack(), linewidth=0.5,ax=ax)

plt.xlabel('UniqueCarrier')
plt.ylabel('Average Delay')
plt.xticks(rotation=450)
plt.legend()
plt.show()
```



In [ ]:
```
q = "Select DT_Hours, UniqueCarrier, min(avg_delays) as least_delays from result2 group by DT_Hours"
df_day = sqldf(q, globals())
df_day
```

Out[ ]:

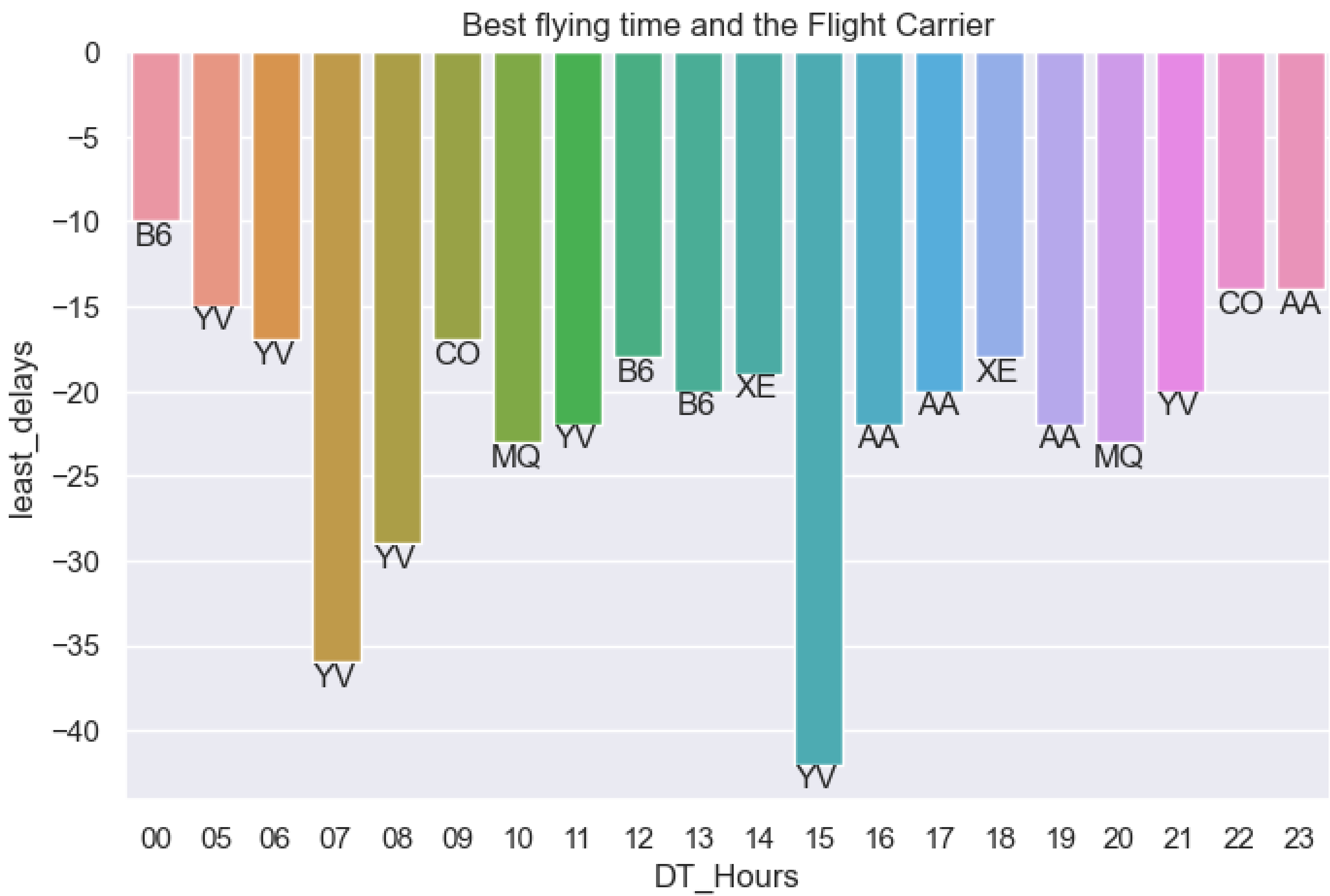
	DT_Hours	UniqueCarrier	least_delays
0	00	B6	-10.0
1	05	YV	-15.0
2	06	YV	-17.0
3	07	YV	-36.0
4	08	YV	-29.0
5	09	CO	-17.0
6	10	MQ	-23.0
7	11	YV	-22.0
8	12	B6	-18.0
9	13	B6	-20.0
10	14	XE	-19.0
11	15	YV	-42.0
12	16	AA	-22.0
13	17	AA	-20.0
14	18	XE	-18.0
15	19	AA	-22.0
16	20	MQ	-23.0
17	21	YV	-20.0
18	22	CO	-14.0
19	23	AA	-14.0

Better graphical representation of best time of flying with minimum delays along with the carrier

In [ ]:

```
#Bar chart representation of the best time to fly on a given day, w.r.t the flight carrier
ax = sns.barplot(data=df_day, x=df_day['DT_Hours'], y=df_day['least_delays'], ci = None)
for container, number in zip(ax.containers, df_day.UniqueCarrier):
    ax.bar_label(container, labels=list(df_day['UniqueCarrier']))
ax.set(title='Best flying time and the Flight Carrier')
```

Out[ ]: [Text(0.5, 1.0, 'Best flying time and the Flight Carrier')]



Investigate what time of the year it is more suited to fly so as to have the delays minimum and does the destination affect this? You can lay insights on some popular destinations for the task.

Affects of time of the year

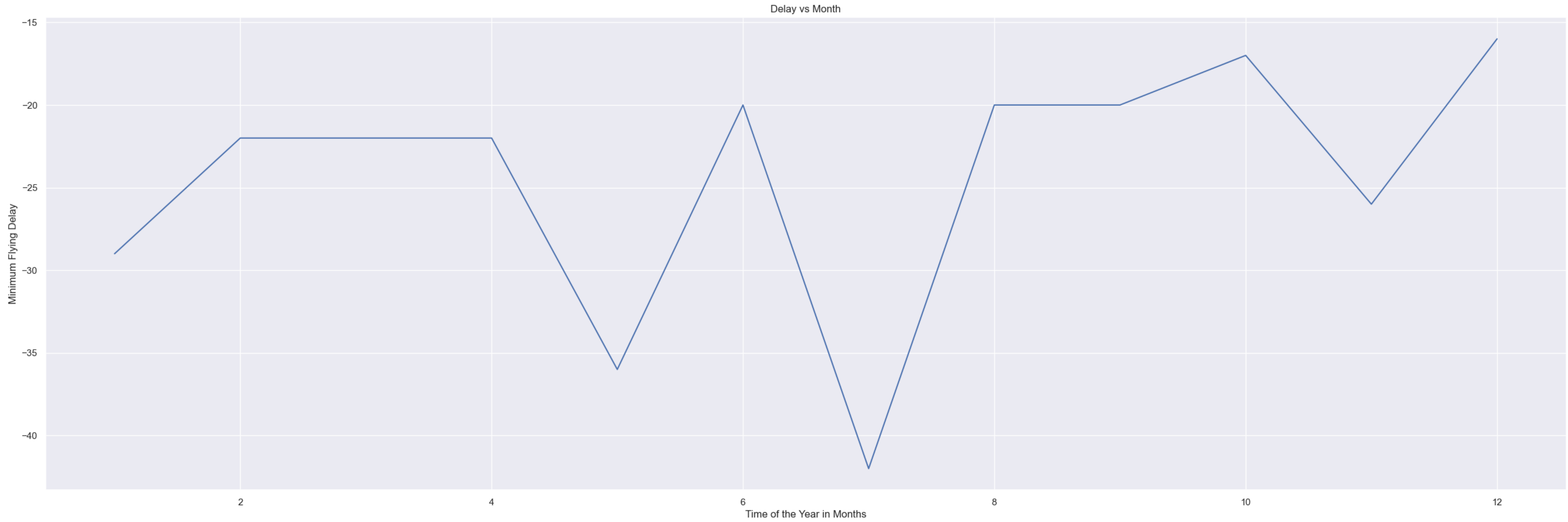
In [ ]:
```
# q = "Select Month, Dest, min(avg_delays) as least_delays from dframe1 group by Month"
# result2 = sqldf(q, globals())
# result2.head(12)
result2 = dframe1.groupby('Month')['avg_delays'].min().reset_index(name='least_delays')
result2
```

Out[ ]:

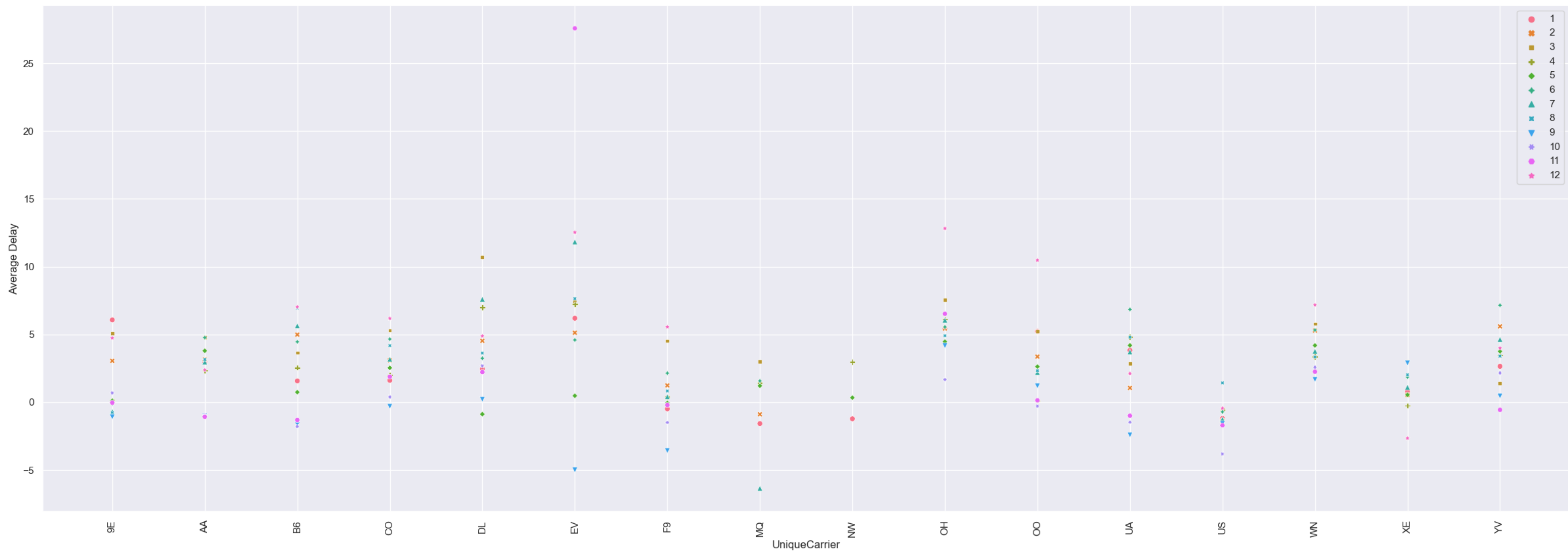
	Month	least_delays
0	1	-29.0
1	2	-22.0
2	3	-22.0
3	4	-22.0
4	5	-36.0
5	6	-20.0
6	7	-42.0
7	8	-20.0
8	9	-20.0
9	10	-17.0
10	11	-26.0
11	12	-16.0

In [ ]:

```
sns.set(rc={'figure.figsize':(32,10)})
ax1 = sns.lineplot(data=result2, x=result2['Month'], y=result2['least_delays'])
ax1.set(xlabel='Time of the Year in Months', ylabel='Minimum Flying Delay', title='Delay vs Month')
plt.show()
```



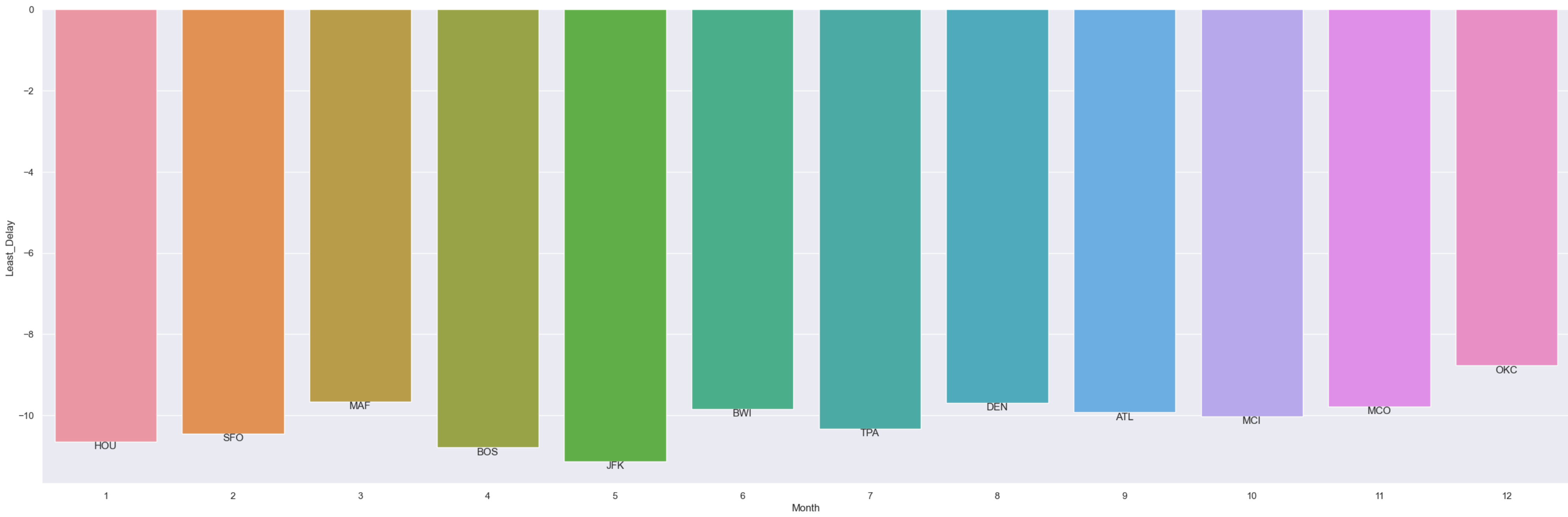
In [ ]:
```
fig, ax = plt.subplots(figsize=(30, 10))
# fig = plt.figure()
sns.scatterplot(dframe1.groupby([dframe1['UniqueCarrier'], 'Month'])['avg_delays'].mean().unstack(), linewidth=0.5,ax=ax)

plt.xlabel('UniqueCarrier')
plt.ylabel('Average Delay')
plt.xticks(rotation=450)
plt.legend()
plt.show()
```



In [ ]:

```
q = "Select Month, Dest, min(avg_delays) as Least_Delay from dframe1 group by Month, Dest"
mydf = sqldf(q, globals())
# mydf.heaed(10)
# ax = sns.barplot(data=mydf, x=mydf['Month'], y=mydf['Least_Delay'], ci = None)
# for container, number in zip(ax.containers, mydf.Dest):
#     ax.bar_label(container, labels = set(list(mydf.Dest)))
# ax.set(title='Time of the Year to Fly with Minimum Delay w.r.t Flight Carriers')
# plt.show()

#Bar chart representation of the best time to fly on a given day, w.r.t the flight carrier
ax = sns.barplot(data=mydf, x=mydf['Month'], y=mydf['Least_Delay'], ci = None)
for container, number in zip(ax.containers, mydf.Dest):
    ax.bar_label(container, labels=list(set(list(mydf['Dest']))))
ax.set(title='Best flying time and the Flight Carrier')
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
Cell In [191], line 13
     11 ax = sns.barplot(data=mydf, x=mydf['Month'], y=mydf['Least_Delay'], ci = None)
     12 for container, number in zip(ax.containers, mydf.Dest):
---> 13     ax.bar_label(container, labels=list(set(list(mydf['Dest']))))
     14 ax.set(title='Best flying time and the Flight Carrier')

File ~/Library/Python/3.9/lib/python/site-packages/matplotlib/axes/_axes.py:2712, in Axes.bar_label(self, container, labels, fm
t, label_type, padding, **kwargs)
   2707 annotations = []
   2709 for bar, err, dat, lbl in itertools.zip_longest(
   2710         bars, errs, datavalues, labels
   2711 ):
-> 2712     (x0, y0), (x1, y1) = bar.get_bbox().get_points()
   2713     xc, yc = (x0 + x1) / 2, (y0 + y1) / 2
   2715     if orientation == "vertical":

AttributeError: 'NoneType' object has no attribute 'get_bbox'
```



You can lay insights on some popular destinations for the task.

In [ ]:
```
#Finding the most popular destination
```

```
dframe1.groupby('Dest')['Dest'].count().sort_values(ascending=False).head(1)
```

Out[ ]:
```
Dest
AUS    49637
Name: Dest, dtype: int64
```

Explore some airports that are bad to fly to. Does the time of day or year affect this?

In [ ]:
```
dframe1.head(5)
```

Out[ ]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	Cancelled	CancellationCode	Div
0	2008	1	1	2	120.0	1935	309.0	2130	9E	5746	...	0	NaN	
1	2008	1	1	2	555.0	0600	826.0	835	AA	1614	...	0	NaN	
2	2008	1	1	2	600.0	0600	728.0	729	YV	2883	...	0	NaN	
3	2008	1	1	2	601.0	0605	727.0	750	9E	5743	...	0	NaN	
4	2008	1	1	2	601.0	0600	654.0	700	AA	1157	...	0	NaN	

5 rows × 31 columns

In [ ]:
```
dframe1['avg_delayWithArrivalDelay'] = dframe1[['DepDelay', 'CarrierDelay', 'WeatherDelay', 'NASDelay', 'SecurityDelay', 'LateA
dframe1.head(10)
```

Out[ ]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	CancellationCode	Diverted	Carr
0	2008	1	1	2	120.0	1935	309.0	2130	9E	5746	...	NaN	0	
1	2008	1	1	2	555.0	0600	826.0	835	AA	1614	...	NaN	0	
2	2008	1	1	2	600.0	0600	728.0	729	YV	2883	...	NaN	0	
3	2008	1	1	2	601.0	0605	727.0	750	9E	5743	...	NaN	0	
4	2008	1	1	2	601.0	0600	654.0	700	AA	1157	...	NaN	0	
5	2008	1	1	2	636.0	0645	934.0	932	NW	1674	...	NaN	0	
6	2008	1	1	2	646.0	0655	735.0	750	CO	340	...	NaN	0	
7	2008	1	1	2	650.0	0700	841.0	857	XE	541	...	NaN	0	
8	2008	1	1	2	650.0	0650	1139.0	1145	AA	1182	...	NaN	0	
9	2008	1	1	2	654.0	0700	1117.0	1133	B6	1060	...	NaN	0	

10 rows × 32 columns

In [ ]:

```
df_day = dframe1.groupby(['Dest'])['avg_delayWithArrivalDelay'].max().reset_index(name='max_delays')
df_day.head(10)
```

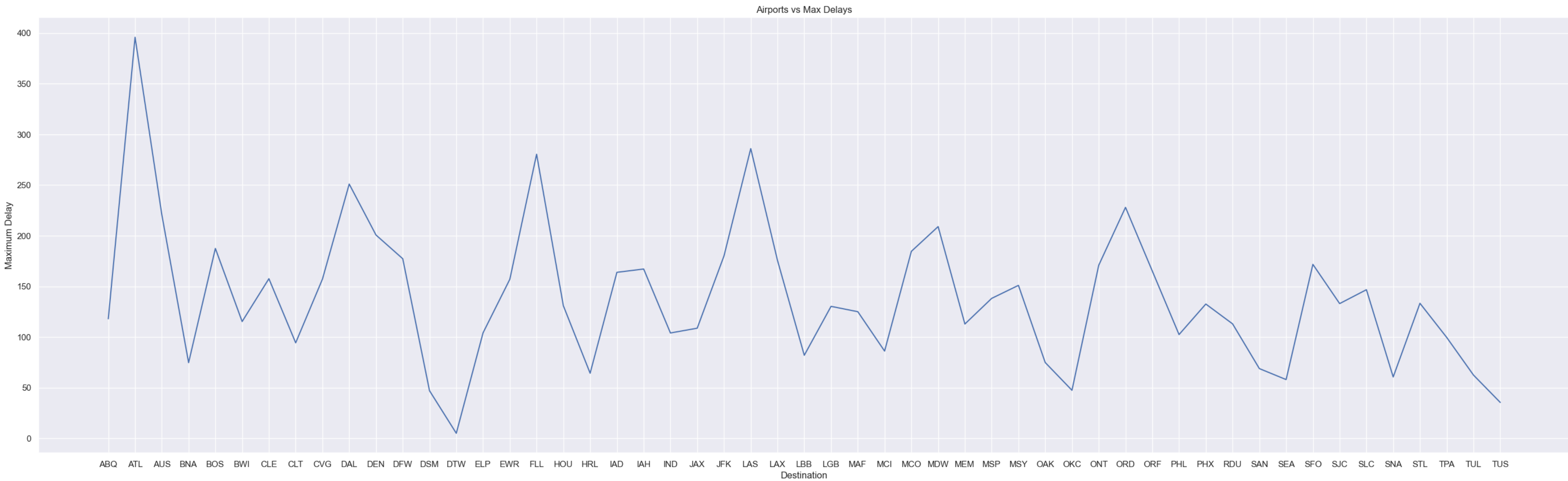
Out[ ]:

	Dest	max_delays
0	ABQ	118.000000
1	ATL	395.857143
2	AUS	220.714286
3	BNA	74.714286
4	BOS	187.428571
5	BWI	115.285714
6	CLE	157.571429
7	CLT	94.285714
8	CVG	157.142857
9	DAL	251.000000

In [ ]:

```
sns.set(rc={'figure.figsize':(35,10)})
```

```
ax = sns.lineplot(x=df_day['Dest'], y=df_day['max_delays'], ci=None)
ax.set(xlabel='Destination', ylabel='Maximum Delay', title='Airports vs Max Delays')
# ax.set_xticks()
plt.show()
```



In [ ]:
```
# #Bar chart representation of the best time to fly on a given day, w.r.t the flight carrier
# sns.set(rc={'figure.figsize':(50,20)})
# ax = sns.barplot(data=df_day, x=df_day['Dest'], y=df_day['Least_Delay'], ci = None)
# for container, number in zip(ax.containers, df_day.Dest):
#     ax.bar_label(container)
# ax.set(title='Best flying time and the Flight Carrier')
# plt.show()
```

In [ ]:
```
dframe1.head(10)
```

Out[ ]:

	Year	Month	DayofMonth	DayOfWeek	DepTime	CRSDepTime	ArrTime	CRSArrTime	UniqueCarrier	FlightNum	...	CancellationCode	Diverted	Carr
0	2008	1	1	2	120.0	1935	309.0	2130	9E	5746	...	NaN	0	
1	2008	1	1	2	555.0	0600	826.0	835	AA	1614	...	NaN	0	
2	2008	1	1	2	600.0	0600	728.0	729	YV	2883	...	NaN	0	
3	2008	1	1	2	601.0	0605	727.0	750	9E	5743	...	NaN	0	
4	2008	1	1	2	601.0	0600	654.0	700	AA	1157	...	NaN	0	
5	2008	1	1	2	636.0	0645	934.0	932	NW	1674	...	NaN	0	
6	2008	1	1	2	646.0	0655	735.0	750	CO	340	...	NaN	0	
7	2008	1	1	2	650.0	0700	841.0	857	XE	541	...	NaN	0	
8	2008	1	1	2	650.0	0650	1139.0	1145	AA	1182	...	NaN	0	
9	2008	1	1	2	654.0	0700	1117.0	1133	B6	1060	...	NaN	0	

10 rows × 32 columns

In [ ]:

```
#Time of the day affects
df_day = dframe1.groupby(['Dest', 'DT_Hours'], as_index=False)['avg_delayWithArrivalDelay'].max().sort_values(by='avg_delayWith
df_day.rename(columns = {'avg_delayWithArrivalDelay':'max_delays'}, inplace = True)
df_day.head(10)
```

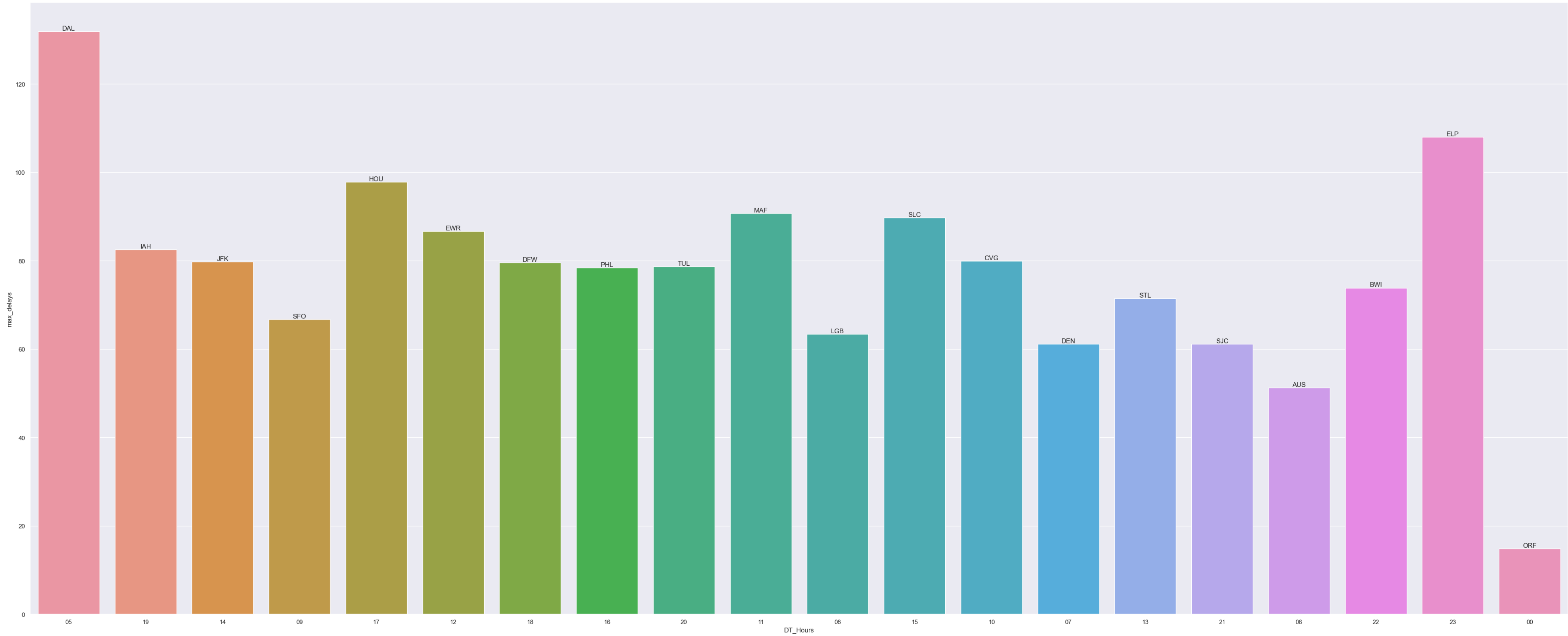
Out[ ]:

	Dest	DT_Hours	max_delays
4	ATL	05	395.857143
208	LAS	19	286.000000
144	FLL	14	280.428571
77	DAL	09	251.000000
289	ORD	17	228.000000
23	AUS	12	220.714286
29	AUS	18	213.000000
27	AUS	16	209.428571
253	MDW	16	209.000000
31	AUS	20	202.142857

In [ ]:
```
d = list(set(list(df_day.Dest)))
```

In [ ]:
```
#Bar chart representation of the best time to fly on a given day, w.r.t the flight carrier
var = list(set(list(df_day.Dest)))
sns.set(rc={'figure.figsize':(50,20)})
ax = sns.barplot(data=df_day, x=df_day['DT_Hours'], y=df_day['max_delays'], ci = None)
for container, number in zip(ax.containers, df_day.Dest):
    ax.bar_label(container, labels=d)
ax.set(title='Worst Airports to Fly w.r.t Months')
plt.show()
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
Cell In [1124], line 6
      4 ax = sns.barplot(data=df_day, x=df_day['DT_Hours'], y=df_day['max_delays'], ci = None)
      5 for container, number in zip(ax.containers, df_day.Dest):
----> 6     ax.bar_label(container, labels=d)
      7 ax.set(title='Worst Airports to Fly w.r.t Months')
      8 plt.show()

File ~/Library/Python/3.9/lib/python/site-packages/matplotlib/axes/_axes.py:2712, in Axes.bar_label(self, container, labels, fm
t, label_type, padding, **kwargs)
   2707 annotations = []
   2709 for bar, err, dat, lbl in itertools.zip_longest(
   2710         bars, errs, datavalues, labels
   2711 ):
-> 2712     (x0, y0), (x1, y1) = bar.get_bbox().get_points()
   2713     xc, yc = (x0 + x1) / 2, (y0 + y1) / 2
   2715     if orientation == "vertical":

AttributeError: 'NoneType' object has no attribute 'get_bbox'
```



In [ ]:

```
#Time of the year affects
df_month = dframe1.groupby(['Dest', 'Month'], as_index=False)['avg_delayWithArrivalDelay'].max().sort_values(by='avg_delayWithA
df_month.rename(columns = {'avg_delayWithArrivalDelay':'max_delays'}, inplace = True)
df_month.head(10)
```

Out[ ]:

	Dest	Month	max_delays
20	ATL	12	395.857143
244	LAS	2	286.000000
162	FLL	7	280.428571
100	DAL	3	251.000000
380	ORD	8	228.000000
27	AUS	7	220.714286
30	AUS	10	213.000000
28	AUS	8	209.428571
319	MDW	2	209.000000
32	AUS	12	202.142857

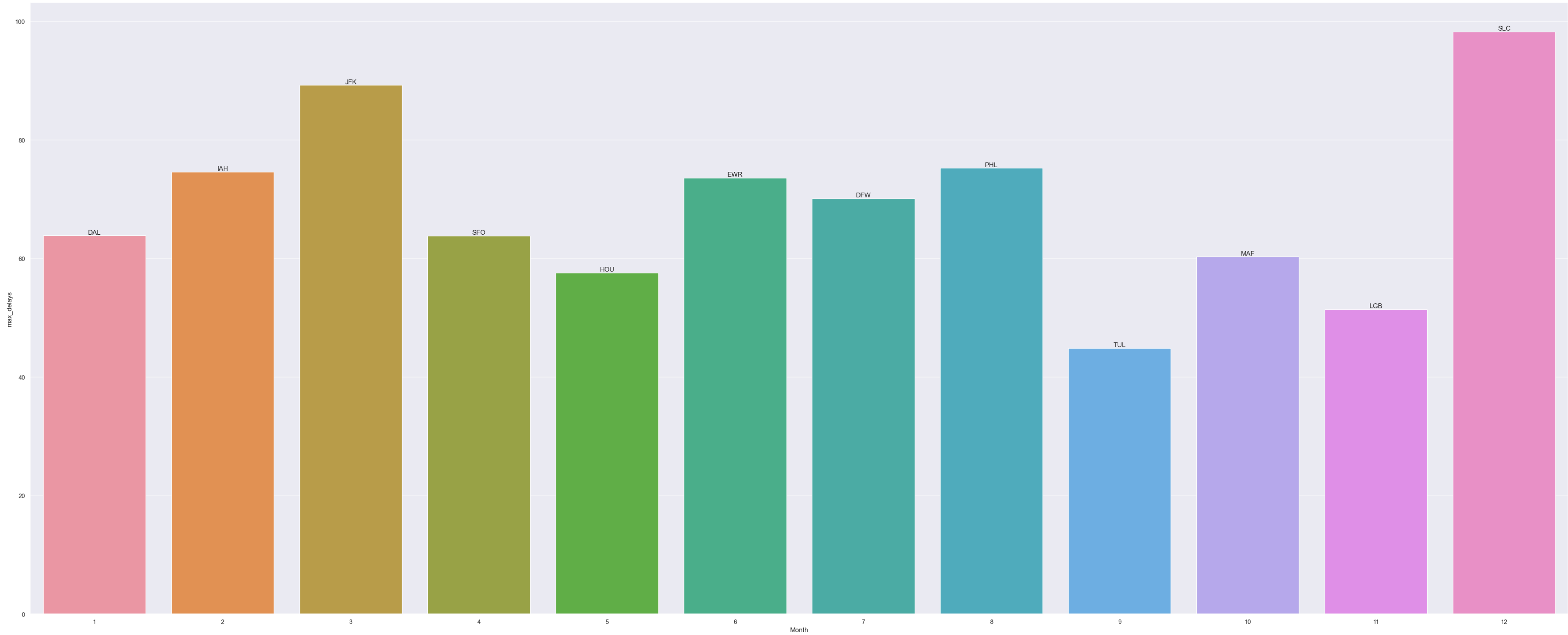
In [ ]:

```
d = list(set(list(df_month.Dest)))
```

In [ ]:

```
#Bar chart representation of the best time to fly on a given day, w.r.t the flight carrier
var = list(set(list(df_month.Dest)))
sns.set(rc={'figure.figsize':(50,20)})
ax = sns.barplot(data=df_day, x=df_month['Month'], y=df_month['max_delays'], ci = None)
for container, number in zip(ax.containers, df_month.Dest):
    ax.bar_label(container, labels=d)
ax.set(title='Worst Airports to Fly w.r.t Months')
plt.show()
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
Cell In [1127], line 6
      4 ax = sns.barplot(data=df_day, x=df_month['Month'], y=df_month['max_delays'], ci = None)
      5 for container, number in zip(ax.containers, df_month.Dest):
----> 6     ax.bar_label(container, labels=d)
      7 ax.set(title='Worst Airports to Fly w.r.t Months')
      8 plt.show()

File ~/Library/Python/3.9/lib/python/site-packages/matplotlib/axes/_axes.py:2712, in Axes.bar_label(self, container, labels, fm
t, label_type, padding, **kwargs)
   2707 annotations = []
   2709 for bar, err, dat, lbl in itertools.zip_longest(
   2710         bars, errs, datavalues, labels
   2711 ):
-> 2712     (x0, y0), (x1, y1) = bar.get_bbox().get_points()
   2713     xc, yc = (x0 + x1) / 2, (y0 + y1) / 2
   2715     if orientation == "vertical":

AttributeError: 'NoneType' object has no attribute 'get_bbox'
```



Investigate on how the pattern of flights to various destinations alter over the course of year.

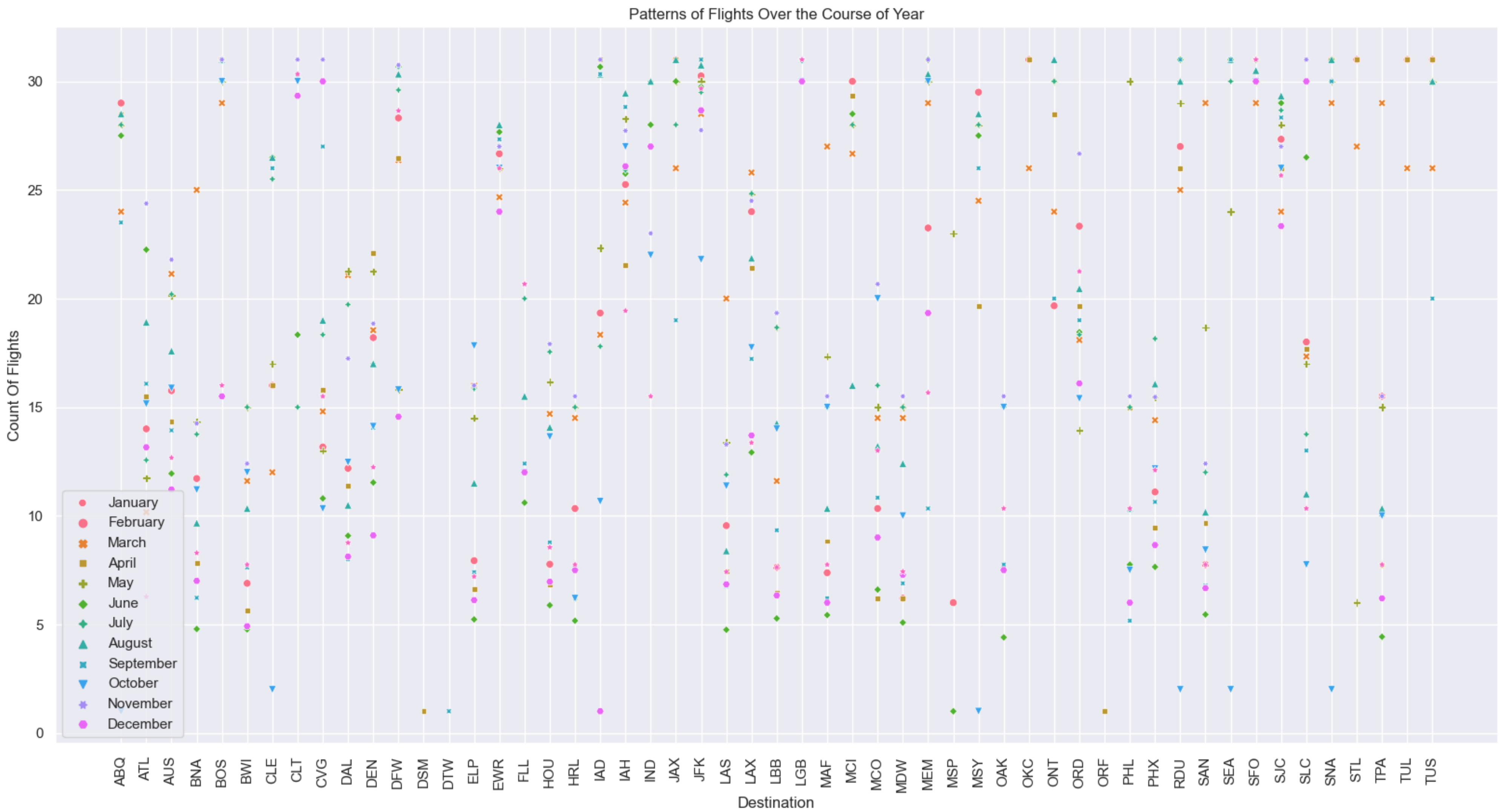
In [ ]:
```
#Pattern of flights over the course of a year along with Flight
result1 = dframe1.groupby(['Month', 'Dest', 'FlightNum'])['FlightNum'].count().reset_index(name='CountOfFlights')
result1.head(10)
```

Out[ ]:

	Month	Dest	FlightNum	CountOfFlights
0	1	ABQ	311	31
1	1	ABQ	315	27
2	1	ATL	466	2
3	1	ATL	470	2
4	1	ATL	1254	1
5	1	ATL	1535	11
6	1	ATL	1590	30
7	1	ATL	3906	2
8	1	ATL	4325	25
9	1	ATL	4338	31

In [ ]:

```
fig, ax = plt.subplots(figsize=(20, 10))
Months = ['January', 'February', 'March', 'April', 'May', 'June', 'July', 'August', 'September', 'October', 'November', 'Decemb
sns.scatterplot(result1.groupby(
[result1['Dest'], 'Month'])['CountOfFlights'].mean().unstack(), linewidth=0.5,ax=ax)
# sns.barplot(TYResult.groupby(
# [TYResult['Dest'], 'Month'])['Min_Delay'].mean().unstack(), linewidth=0.5,ax=ax)
plt.xlabel('Destination')
plt.ylabel('Count Of Flights')
plt.title('Patterns of Flights Over the Course of Year')
plt.xticks(rotation=450)
plt.legend(Months)
plt.show()
```



Question 2

In this part we will examine the data containing information on every Olympic medallist that is listed by participant count in top 20 sports, dating back to 1896. Load the dataset task2.txt and perform statistical analysis on the dataset. Specifically, do the following:

In [ ]:
```
df = pd.read_csv("/Users/farjad.ahmed/Documents/Studies/ML Lab/Exercise_01/task2.txt")
```

In [ ]:
```
#Displaying all the necessary information from the file
df.head()
```

Out[ ]:

	id	name	sex	age	height	weight	team	noc	games	year	season	city	sport	event	medal
0	16	Juhamatti Tapio Aaltonen	M	28	184	85.0	Finland	FIN	2014 Winter	2014	Winter	Sochi	Ice Hockey	Ice Hockey Men's Ice Hockey	Bronze
1	17	Paavo Johannes Aaltonen	M	28	175	64.0	Finland	FIN	1948 Summer	1948	Summer	London	Gymnastics	Gymnastics Men's Individual All-Around	Bronze
2	17	Paavo Johannes Aaltonen	M	28	175	64.0	Finland	FIN	1948 Summer	1948	Summer	London	Gymnastics	Gymnastics Men's Team All-Around	Gold
3	17	Paavo Johannes Aaltonen	M	28	175	64.0	Finland	FIN	1948 Summer	1948	Summer	London	Gymnastics	Gymnastics Men's Horse Vault	Gold
4	17	Paavo Johannes Aaltonen	M	28	175	64.0	Finland	FIN	1948 Summer	1948	Summer	London	Gymnastics	Gymnastics Men's Pommelled Horse	Gold

Compute the 95th percentile of heights for the competitors in all Athletic events for gender Female. Note that sport refers to the broad sports (Athletics) and event is the specific event (100-meter sprint).

In [ ]:
```
df_1 = df[(df['sex']=='F') & (df['sport']=='Athletics') ]
df_1['height'].quantile(0.95)
```

Out[ ]:
```
183.0
```

Find the single woman’s event that depicts the highest variability in the height of the competitor across the entire history of Olympics. Use the standard deviation as the yardstick for this.

In [ ]:
```
df_2 = df[(df['sex']=='F')]
#This could be done in two ways
#1
df_2.groupby('event')['height'].std().sort_values(ascending=False).reset_index(name='std').head(1)
```

Out[ ]:

	event	std
0	Rowing Women's Coxed Fours	10.86549

In [ ]:
```
#2
df_2 = df_2.groupby('event')['height'].std()
df_2 = df_2.to_frame()
df_2['height'].idxmax()
```

Out[ ]: "Rowing Women's Coxed Fours"

We wish to know how the average age of swimmers in Olympic has evolved with time. How has this changed over time? Does the trend for this differs from male to female? It will be easy to create a data frame that will allow one to visualise these trends with time. Plot a line graph that depicts separate line for male and female competitors. The plot must have a caption that is informative enough to answer the 2 questions that have been asked in this part.

In [ ]:
```
#Creating two dataframes, one for females and the other for males
df_F = df[df['sex']=='F']
df_M = df[df['sex']=='M']
```

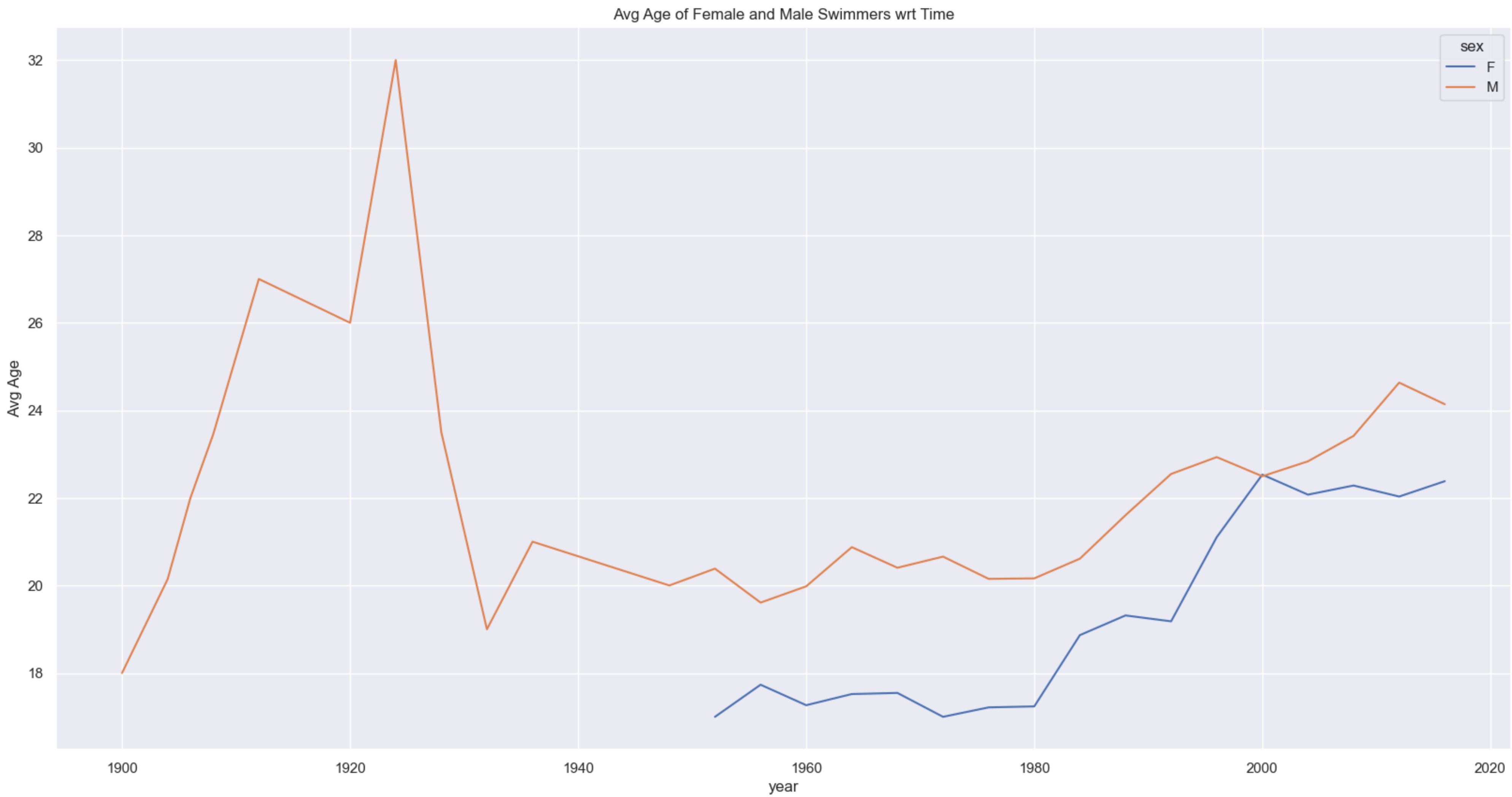
In [ ]:
```
df_M1 = df_M.groupby('year')['age'].agg('mean')
df_M1 = df_M1.to_frame()
# df_M1
```

In [ ]:
```
df_F1 = df_F.groupby('year')['age'].agg('mean')
df_F1 = df_F1.to_frame()
# df_F1
```

Here I see this is not the best method of doing this, I will have to join these two dataframes for female avg ages and male avg ages. Instead I found an easier method by using unstack to do this, shown below.

In [ ]:
```
df_s = df[(df['sport']=='Swimming')]
```

In [ ]:
```
# This is an easy way of doing this
sns.set(rc={'figure.figsize':(20,10)})
out = df_s.groupby(['year','sex'])['age'].agg('mean').unstack()
out.plot(xlabel='year', ylabel='Avg Age', title='Avg Age of Female and Male Swimmers wrt Time')
plt.show()
```



Avg Age of Female and Male Swimmers wrt Time
sex
F
M
32
30
28
26
24
22
20
18
Avg Age
1900
1920
1940
1960
1980
2000
2020
year