```
# install
!pip install pmdarima
```

```
Requirement already satisfied: pmdarima in /usr/local/lib/python3.10/dist-packages (2.0.4)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (1.4.2)
Requirement already satisfied: Cython!=0.29.18,!=0.29.31,>=0.29 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (3.0.11)
Requirement already satisfied: numpy>=1.21.2 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (1.26.4)
Requirement already satisfied: pandas>=0.19 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (2.2.2)
Requirement already satisfied: scikit-learn>=0.22 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (1.5.2)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (1.13.1)
Requirement already satisfied: statsmodels>=0.13.2 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (0.14.4)
Requirement already satisfied: urllib3 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (2.2.3)
Requirement already satisfied: setuptools!=50.0.0,>=38.6.0 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (75.1.0)
Requirement already satisfied: packaging>=17.1 in /usr/local/lib/python3.10/dist-packages (from pmdarima) (24.2)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.10/dist-packages (from pandas>=0.19->pmdarima) (2024.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=0.22->pmdarima) (3.5.
Requirement already satisfied: patsy>=0.5.6 in /usr/local/lib/python3.10/dist-packages (from statsmodels>=0.13.2->pmdarima) (1.0.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2->pandas>=0.19->pmdarima)
```

```
# Import Packages
import pandas as pd
import numpy as np


# Mount the cloud folder for data file storage
from google.colab import drive
drive.mount('/content/gdrive', force_remount=True)
csvFile = "/content/gdrive/MyDrive/Colab Notebooks/kz.csv"

# reading the csv file to get symptoms and outcomes data
df_data = pd.read_csv(csvFile)
data = pd.read_csv(csvFile)
```

```
Mounted at /content/gdrive
```

```
# Loading the dataset
df_data['event_time'] = df_data['event_time'].replace(" UTC","", regex=True)
df_data['event_time'] = pd.to_datetime(df_data['event_time'])
df_data
```

	event_time	order_id	product_id	category_id	category_code	brand	price	user_id
0	2020-04-24 11:50:39	2294359932054536986	1515966223509089906	2.268105e+18	electronics.tablet	samsung	162.01	1.515916e+18
1	2020-04-24 11:50:39	2294359932054536986	1515966223509089906	2.268105e+18	electronics.tablet	samsung	162.01	1.515916e+18
2	2020-04-24 14:37:43	2294444024058086220	2273948319057183658	2.268105e+18	electronics.audio.headphone	huawei	77.52	1.515916e+18
3	2020-04-24 14:37:43	2294444024058086220	2273948319057183658	2.268105e+18	electronics.audio.headphone	huawei	77.52	1.515916e+18
4	2020-04-24 19:16:21	2294584263154074236	2273948316817424439	2.268105e+18	NaN	karcher	217.57	1.515916e+18
...	...	...	...	...	...	...	...	...
2633516	2020-11-21 10:10:01	2388440981134693942	1515966223526602848	2.268105e+18	electronics.smartphone	oppo	138.87	1.515916e+18
2633517	2020-11-21 10:10:13	2388440981134693943	1515966223509089282	2.268105e+18	electronics.smartphone	apple	418.96	1.515916e+18

```
# Data transaformation
# Split the categories into sub categories
df_data[['l1_cat', 'l2_cat', 'l3_cat']] = df_data['category_code'].str.split('.',expand=True)

df_data
```

	event_time	order_id	product_id	category_id	category_code	brand	price	user_id	
0	2020-04-24 11:50:39	2294359932054536986	1515966223509089906	2.268105e+18	electronics.tablet	samsung	162.01	1.515916e+18	ele
1	2020-04-24 11:50:39	2294359932054536986	1515966223509089906	2.268105e+18	electronics.tablet	samsung	162.01	1.515916e+18	ele
2	2020-04-24 14:37:43	2294444024058086220	2273948319057183658	2.268105e+18	electronics.audio.headphone	huawei	77.52	1.515916e+18	ele
3	2020-04-24 14:37:43	2294444024058086220	2273948319057183658	2.268105e+18	electronics.audio.headphone	huawei	77.52	1.515916e+18	ele
4	2020-04-24 19:16:21	2294584263154074236	2273948316817424439	2.268105e+18	NaN	karcher	217.57	1.515916e+18	
...	...	...	...	...	...	...	...	...	
2633516	2020-11-21 10:10:01	2388440981134693942	1515966223526602848	2.268105e+18	electronics.smartphone	oppo	138.87	1.515916e+18	ele
2633517	2020-11-21 10:10:13	2388440981134693943	1515966223509089282	2.268105e+18	electronics.smartphone	apple	418.96	1.515916e+18	ele

```
# Describe Data + some data cleaning
df_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2633521 entries, 0 to 2633520
Data columns (total 11 columns):
 #   Column         Dtype
---  ------         -----
 0   event_time     datetime64[ns]
 1   order_id       int64
 2   product_id     int64
 3   category_id    float64
 4   category_code  object
 5   brand          object
 6   price          float64
 7   user_id        float64
 8   l1_cat         object
 9   l2_cat         object
 10  l3_cat         object
dtypes: datetime64[ns](1), float64(3), int64(2), object(5)
memory usage: 221.0+ MB
```

```
df_data.describe()
```

	event_time	order_id	product_id	category_id	price	user_id
count	2633521	2.633521e+06	2.633521e+06	2.201567e+06	2.201567e+06	5.641690e+05
mean	2020-01-16 19:57:05.412119808	2.361783e+18	1.674080e+18	2.273827e+18	1.540932e+02	1.515916e+18
min	1970-01-01 00:33:40	2.294360e+18	1.515966e+18	2.268105e+18	0.000000e+00	1.515916e+18
25%	2020-03-05 15:42:44	2.348807e+18	1.515966e+18	2.268105e+18	1.456000e+01	1.515916e+18
50%	2020-06-08 08:33:27	2.353254e+18	1.515966e+18	2.268105e+18	5.553000e+01	1.515916e+18
75%	2020-08-24 06:52:14	2.383131e+18	1.515966e+18	2.268105e+18	1.967400e+02	1.515916e+18
max	2020-11-21 10:10:30	2.388441e+18	2.388434e+18	2.374499e+18	5.092590e+04	1.515916e+18
std	NaN	1.716538e+16	3.102249e+17	2.353247e+16	2.419421e+02	2.379057e+07

```
# calculate percentage of missing value
df_data.isnull().sum()/len(df_data)
```

	0
event_time	0.000000
order_id	0.000000
product_id	0.000000
category_id	0.164021
category_code	0.232465
brand	0.192140
price	0.164021
user_id	0.785774
l1_cat	0.232465
l2_cat	0.232465
l3_cat	0.626633

dtype: float64

```
print("Min Date: ", df_data['event_time'].min())
print("Max Date: ", df_data['event_time'].max())
```

```
Min Date:  1970-01-01 00:33:40
Max Date:  2020-11-21 10:10:30
```

```
df_data['year'] = df_data['event_time'].dt.year
df_data.groupby(['year'])['year'].count()
```

	year
year	
1970	19631
2020	2613890

dtype: int64

```
df_data = df_data[df_data['year'] != 1970].reset_index(drop=True)
```

```
df_data = df_data[df_data['user_id'].notna()].reset_index(drop=True)
```

```
# Handling missing price values
products_median_prices = df_data.groupby(['product_id'])['price'].median().reset_index()
products_median_prices = pd.Series(df_data['price'].values, index=df_data['product_id']).to_dict()

# fill in missing prices with the median
df_data['price'] = df_data['price'].fillna(df_data['product_id'].map(products_median_prices))
df_data['price'].isna().sum()
```

```
0
```

```
# Import libraries - 2
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

from pmdarima.arima import auto_arima
from sklearn.metrics import mean_squared_error
from pandas.plotting import autocorrelation_plot

from statsmodels.tsa.arima.model import ARIMA
from statsmodels.tsa.stattools import adfuller, kpss
from statsmodels.tsa.seasonal import seasonal_decompose
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.nonparametric.smoothers_lowess import lowess

import warnings
warnings.filterwarnings('ignore')
```

```
# drop all other columns except the two below
data = data[['event_time', 'price']]
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2633521 entries, 0 to 2633520
Data columns (total 2 columns):
 #   Column      Dtype  
---  ------      -----  
 0   event_time  object 
 1   price       float64
dtypes: float64(1), object(1)
memory usage: 40.2+ MB
```

```
# data preprocessing
data = data.drop_duplicates()
data.isnull().sum()
```

```
                 0
event_time       0
     price  241375

dtype: int64
```

```
# remove rows where 'price' contains NaNs
data = data[~data['price'].isnull()]
data
```

```
                     event_time    price
      0  2020-04-24 11:50:39 UTC  162.01
      2  2020-04-24 14:37:43 UTC   77.52
      4  2020-04-24 19:16:21 UTC  217.57
      5  2020-04-26 08:45:57 UTC   39.33
      6  2020-04-26 09:33:47 UTC 1387.01
    ...                      ...      ...
2633516  2020-11-21 10:10:01 UTC  138.87
2633517  2020-11-21 10:10:13 UTC  418.96
2633518  2020-11-21 10:10:30 UTC   12.48
2633519  2020-11-21 10:10:30 UTC   41.64
2633520  2020-11-21 10:10:30 UTC   53.22
2139643 rows × 2 columns
```

```
data.isnull().sum()
```

	0
event_time	0
price	0

dtype: int64

```
data.describe(include='all')
```

	event_time	price
count	2139643	2.139643e+06
unique	1299919	NaN
top	1970-01-01 00:33:40 UTC	NaN
freq	674	NaN
mean	NaN	1.557634e+02
std	NaN	2.436082e+02
min	NaN	0.000000e+00
25%	NaN	1.502000e+01
50%	NaN	5.785000e+01
75%	NaN	2.013700e+02
max	NaN	5.092590e+04

```
# exclude event_time rows that contain 1970
data = data[~data['event_time'].str.contains('1970')]
#remove UTC from event_time
data['event_time'] = data['event_time'].str.replace('UTC','')
data.describe(include='all')
```

	event_time	price
count	2138969	2.138969e+06
unique	1299918	NaN
top	2020-04-09 16:30:01	NaN
freq	155	NaN
mean	NaN	1.557135e+02
std	NaN	2.434253e+02
min	NaN	0.000000e+00
25%	NaN	1.502000e+01
50%	NaN	5.785000e+01
75%	NaN	2.013700e+02
max	NaN	5.092590e+04

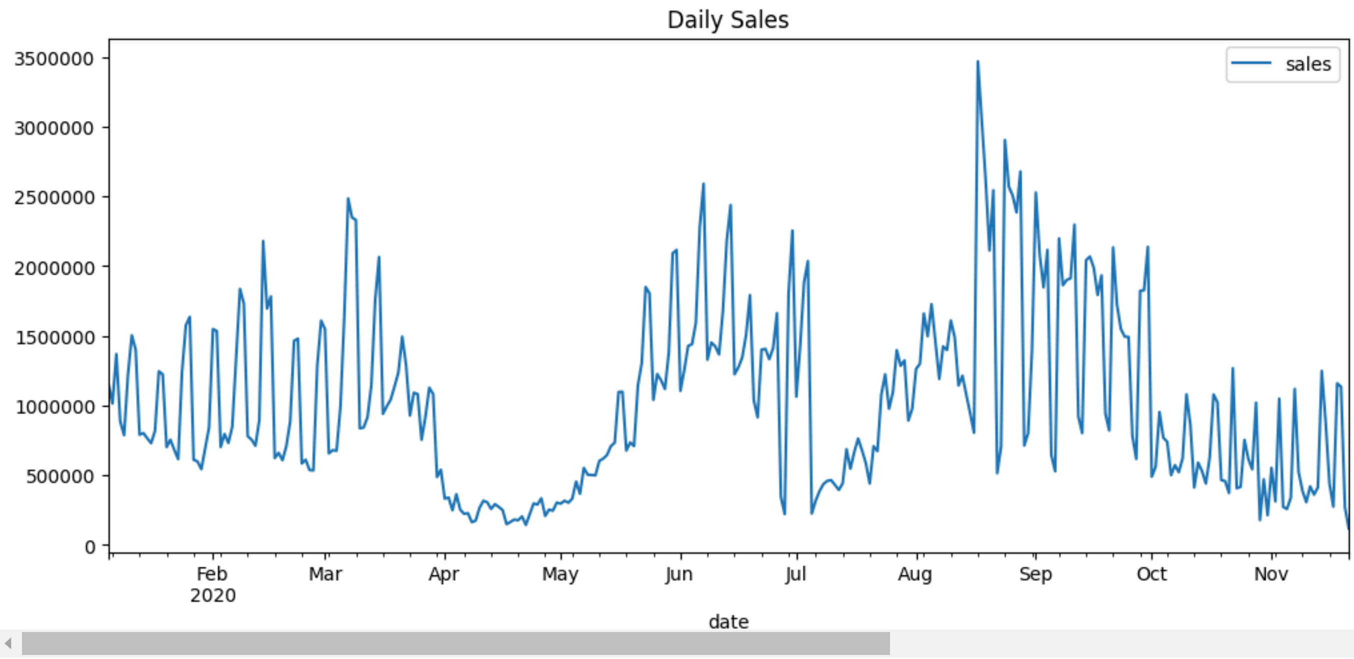
```
# create date column
data['date'] = data.event_time.apply(lambda x: x.split(' ')[0])

# convert to datetime object
data['date'] = pd.to_datetime(data['date'])
# delete event_time column
del data['event_time']
data.head()
```

```
      price        date
0    162.01  2020-04-24
2     77.52  2020-04-24
4    217.57  2020-04-24
5     39.33  2020-04-26
6   1387.01  2020-04-26
```

```
# create a new time series
df = data.groupby('date').agg(sales=('price', 'sum'))
df.head()
```

```
                 sales
      date
2020-01-05  1151017.74
2020-01-06  1014544.86
2020-01-07  1369143.81
2020-01-08   886054.44
2020-01-09   787447.75
```

```
# visualize the time series data
fig, ax = plt.subplots()
plt.ticklabel_format(style='plain')
fig = df.plot(figsize=(12,5), ax=ax)
plt.title('Daily Sales')
plt.show()
```



```
# Define RFM Dataset - 1
from pandas.tseries.offsets import MonthEnd

df_data['month_key'] = df_data['event_time'].dt.month
df_data[['event_time', 'month_key']]
```

```
                 event_time  month_key
0       2020-04-24 11:50:39          4
1       2020-04-24 11:50:39          4
2       2020-04-24 14:37:43          4
3       2020-04-24 14:37:43          4
4       2020-04-24 19:16:21          4
...                     ...        ...
562857  2020-11-21 10:10:01         11
562858  2020-11-21 10:10:13         11
562859  2020-11-21 10:10:30         11
562860  2020-11-21 10:10:30         11
562861  2020-11-21 10:10:30         11

562862 rows × 2 columns
```

```
# creating a new dataframe
df_month_keys = pd.DataFrame({"month_key":df_data['month_key'].unique(), 'key':0})
df_user_ids = pd.DataFrame({"user_id":df_data['user_id'].unique(), 'key':0})

df_rfm = df_month_keys.merge(df_user_ids, on='key', how='outer')
df_rfm = df_rfm.drop(columns=['key'])
df_rfm = df_rfm.sort_values(by=['user_id', 'month_key']).reset_index(drop=True)
df_rfm
```

```
          month_key       user_id
0                 1  1.515916e+18
1                 2  1.515916e+18
2                 3  1.515916e+18
3                 4  1.515916e+18
4                 5  1.515916e+18
...             ...           ...
1080679           7  1.515916e+18
1080680           8  1.515916e+18
1080681           9  1.515916e+18
1080682          10  1.515916e+18
1080683          11  1.515916e+18

1080684 rows × 2 columns
```

```
# Recency
# User last month purchase
df_user_month_purchases = df_data[['month_key', 'user_id']].drop_duplicates()
df_user_month_purchases['last_purchase'] = df_user_month_purchases['month_key']

df_rfm = df_rfm.merge(df_user_month_purchases, how='left', on=['month_key', 'user_id'])

# filling the last_purchase month
user_ids = df_rfm[['user_id']]
df_rfm = df_rfm.groupby('user_id').ffill()
df_rfm['R_months_since_last_purchase'] = df_rfm['month_key'] - df_rfm['last_purchase']
df_rfm['user_id'] = user_ids
df_rfm.head(20)
```

	month_key	last_purchase	R_months_since_last_purchase	user_id
0	1	NaN	NaN	1.515916e+18
1	2	NaN	NaN	1.515916e+18
2	3	NaN	NaN	1.515916e+18
3	4	NaN	NaN	1.515916e+18
4	5	NaN	NaN	1.515916e+18
5	6	NaN	NaN	1.515916e+18
6	7	7.0	0.0	1.515916e+18
7	8	7.0	1.0	1.515916e+18
8	9	7.0	2.0	1.515916e+18
9	10	7.0	3.0	1.515916e+18
10	11	7.0	4.0	1.515916e+18
11	1	NaN	NaN	1.515916e+18
12	2	NaN	NaN	1.515916e+18
13	3	NaN	NaN	1.515916e+18
14	4	NaN	NaN	1.515916e+18
15	5	NaN	NaN	1.515916e+18

```
# Frequency
# user last month purchase order count
df_user_month_purchases = df_data.groupby(['month_key', 'user_id'])['order_id'].nunique().reset_index()
df_rfm = df_rfm.merge(df_user_month_purchases, how='left', on=['month_key', 'user_id'])

# filling the last_purchase month
user_ids = df_rfm[['user_id']]
df_rfm = df_rfm.groupby('user_id').ffill()
df_rfm['user_id'] = user_ids
df_rfm = df_rfm.rename(columns={"order_id":"F_last_monthly_purchases_count"})
df_rfm.head(20)
```

	month_key	last_purchase	R_months_since_last_purchase	F_last_monthly_purchases_count	user_id