New York City Yellow Taxi Data

Objective

In this case study you will be learning exploratory data analysis (EDA) with the help of a dataset on yellow taxi rides in New York City. This will enable you to understand why EDA is an important step in the process of data science and machine learning.

Problem Statement

As an analyst at an upcoming taxi operation in NYC, you are tasked to use the 2023 taxi trip data to uncover insights that could help optimise taxi operations. The goal is to analyse patterns in the data that can inform strategic decisions to improve service efficiency, maximise revenue, and enhance passenger experience.

Tasks

You need to perform the following steps for successfully completing this assignment:

1. Data Loading
2. Data Cleaning
3. Exploratory Analysis: Bivariate and Multivariate
4. Creating Visualisations to Support the Analysis
5. Deriving Insights and Stating Conclusions

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Data Understanding

The yellow taxi trip records include fields capturing pick-up and drop-off dates/times, pick-up and drop-off locations, trip distances, itemized fares, rate types, payment types, and driver-reported passenger counts.

The data is stored in Parquet format (*.parquet*). The dataset is from 2009 to 2024. However, for this assignment, we will only be using the data from 2023.

The data for each month is present in a different parquet file. You will get twelve files for each of the months in 2023.

The data was collected and provided to the NYC Taxi and Limousine Commission (TLC) by technology providers like vendors and taxi hailing apps.

You can find the link to the TLC trip records page here: https://www.nyc.gov/site/tlc/about/tlc-trip-record-data.page

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1 Data Preparation

[5 marks]

Import Libraries

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1.1 Load the dataset

[5 marks]

You will see twelve files, one for each month.

To read parquet files with Pandas, you have to follow a similar syntax as that for CSV files.

```
df = pd.read_parquet('file.parquet')
```

```
# Try loading one file

# df = pd.read_parquet('2023-1.parquet')
# df.info()
```

```
from google.colab import files
uploaded = files.upload()

df = pd.read_parquet("2023-1.parquet")  # Replace with actual filename
df.info()
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving 2023-1.parquet to 2023-1.parquet
<class 'pandas.core.frame.DataFrame'>
Index: 3041714 entries, 0 to 3066765
Data columns (total 19 columns):
 #   Column                 Dtype
---  ------                 -----
 0   VendorID               int64
 1   tpep_pickup_datetime   datetime64[us]
 2   tpep_dropoff_datetime  datetime64[us]
 3   passenger_count        float64
 4   trip_distance          float64
 5   RatecodeID             float64
 6   store_and_fwd_flag     object
 7   PULocationID           int64
 8   DOLocationID           int64
 9   payment_type           int64
 10  fare_amount            float64
 11  extra                  float64
 12  mta_tax                float64
 13  tip_amount             float64
 14  tolls_amount           float64
 15  improvement_surcharge  float64
 16  total_amount           float64
 17  congestion_surcharge   float64
 18  airport_fee            float64
dtypes: datetime64[us](2), float64(12), int64(4), object(1)
```

How many rows are there? Do you think handling such a large number of rows is computationally feasible when we have to combine the data for all twelve months into one?

To handle this, we need to sample a fraction of data from each of the files. How to go about that? Think of a way to select only some portion of the data from each month's file that accurately represents the trends.

Sampling the Data

> One way is to take a small percentage of entries for pickup in every hour of a date. So, for all the days in a month, we can iterate through the hours and select 5% values randomly from those. Use `tpep_pickup_datetime` for this. Separate date and hour from the datetime values and then for each date, select some fraction of trips for each of the 24 hours.

To sample data, you can use the `sample()` method. Follow this syntax:

```
# sampled_data is an empty DF to keep appending sampled data of each hour
# hour_data is the DF of entries for an hour 'X' on a date 'Y'

sample = hour_data.sample(frac = 0.05, random_state = 42)
# sample 0.05 of the hour_data
# random_state is just a seed for sampling, you can define it yourself

sampled_data = pd.concat([sampled_data, sample]) # adding data for this hour to the DF
```

This *sampled_data* will contain 5% values selected at random from each hour.

Note that the code given above is only the part that will be used for sampling and not the complete code required for sampling and combining the data files.

Keep in mind that you sample by date AND hour, not just hour. (Why?)

```
# Extracting  date and hour from pickup datetime
df['pickup_date'] = df['tpep_pickup_datetime'].dt.date
df['pickup_hour'] = df['tpep_pickup_datetime'].dt.hour

#Creating an empty DataFrame to hold all samples
sampled_data = pd.DataFrame()

# Iterate over each date
unique_dates = df['pickup_date'].unique()

for date in unique_dates:
```

```
    # For each hour in the 24-hour day
    for hour in range(24):
        # Get data for the specific hour of the date
        hour_data = df[(df['pickup_date'] == date) & (df['pickup_hour'] == hour)]

        # Only sample if data exists for that hour
        if not hour_data.empty:
            # Sample 5% of the data
            sample = hour_data.sample(frac=0.05, random_state=42)
            # Append to the sampled dataset
            sampled_data = pd.concat([sampled_data, sample], ignore_index=True)


print("Original dataset size:", len(df))
print("Sampled dataset size (5% per hour per date):", len(sampled_data))
```

```
Original dataset size: 3041714
Sampled dataset size (5% per hour per date): 152087
```

1.1.1 [5 marks]

Figure out how to sample and combine the files.

Note: It is not mandatory to use the method specified above. While sampling, you only need to make sure that your sampled data represents the overall data of all the months accurately.

```
# Sample the data
# It is recommmended to not load all the files at once to avoid memory overload


# from google.colab import drive
# drive.mount('/content/drive')


# Take a small percentage of entries from each hour of every date.
# Iterating through the monthly data:
#   read a month file -> day -> hour: append sampled data -> move to next hour -> move to next day after 24 hours -> move to next month
# Create a single dataframe for the year combining all the monthly data

# Select the folder having data files
import pandas as pd
import os
from google.colab import drive

# Mount Google Drive
drive.mount('/content/drive')

# Define the path to the folder where your .parquet files are stored
data_folder_path = '/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI'

# List files inside that folder
file_list = sorted(os.listdir(data_folder_path))  # Ensure files are sorted by month

# Initialize empty DataFrame to collect sampled data
df_yearly_sample = pd.DataFrame()

# Loop through all monthly files
for file_name in file_list:
    try:
        print(f"📁 Processing: {file_name}")
        file_path = os.path.join(data_folder_path, file_name)

        # Load the month's data
        df_month = pd.read_parquet(file_path)

        # Ensure datetime is in correct format
        df_month['tpep_pickup_datetime'] = pd.to_datetime(df_month['tpep_pickup_datetime'])

        # Extract date and hour
        df_month['pickup_date'] = df_month['tpep_pickup_datetime'].dt.date
        df_month['pickup_hour'] = df_month['tpep_pickup_datetime'].dt.hour

        # Initialize container for this month's sampled data
        sampled_month = pd.DataFrame()

        # Loop through each date and hour
        for date in df_month['pickup_date'].unique():
            for hour in range(24):
```

```
                hour_data = df_month[(df_month['pickup_date'] == date) & (df_month['pickup_hour'] == hour)]
                if not hour_data.empty:
                    sample = hour_data.sample(frac=0.05, random_state=42)
                    sampled_month = pd.concat([sampled_month, sample], ignore_index=True)

        # Append to final yearly sample
        df_yearly_sample = pd.concat([df_yearly_sample, sampled_month], ignore_index=True)
        print(f"✅ {file_name} done | Sampled: {len(sampled_month)} rows")

    except Exception as e:
        print(f"❌ Error processing {file_name}: {e}")

# Done!
print(f"\n🎉 Sampling complete! Total sampled rows for the year: {len(df_yearly_sample)}")
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
📁 Processing: 2023-1.parquet
✅ 2023-1.parquet done | Sampled: 152087 rows
📁 Processing: 2023-10.parquet
✅ 2023-10.parquet done | Sampled: 174255 rows
📁 Processing: 2023-11.parquet
✅ 2023-11.parquet done | Sampled: 165133 rows
📁 Processing: 2023-12.parquet
✅ 2023-12.parquet done | Sampled: 166709 rows
📁 Processing: 2023-2.parquet
✅ 2023-2.parquet done | Sampled: 168696 rows
📁 Processing: 2023-3.parquet
✅ 2023-3.parquet done | Sampled: 163786 rows
📁 Processing: 2023-4.parquet
✅ 2023-4.parquet done | Sampled: 139641 rows
📁 Processing: 2023-5.parquet
✅ 2023-5.parquet done | Sampled: 144458 rows
📁 Processing: 2023-6.parquet
✅ 2023-6.parquet done | Sampled: 162910 rows
📁 Processing: 2023-7.parquet
✅ 2023-7.parquet done | Sampled: 174068 rows
📁 Processing: 2023-8.parquet
✅ 2023-8.parquet done | Sampled: 143782 rows
📁 Processing: 2023-9.parquet
✅ 2023-9.parquet done | Sampled: 140875 rows

🎉 Sampling complete! Total sampled rows for the year: 1896400
```

```
df_yearly_sample.to_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-4-e7fdb04e94f9> in <cell line: 0>()
----> 1 df_yearly_sample.to_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')

NameError: name 'df_yearly_sample' is not defined
```

Next steps: Explain error

After combining the data files into one DataFrame, convert the new DataFrame to a CSV or parquet file and store it to use directly.

Ideally, you can try keeping the total entries to around 250,000 to 300,000.

```
# Store the df in csv/parquet
# df.to_parquet('')
df_yearly_sample.to_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')
```

2 Data Cleaning

[30 marks]

Now we can load the new data directly.

```
# Load the new data file

import pandas as pd

# Load the saved sampled dataset
df = pd.read_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')
```

```
---------------------------------------------------------------------------
FileNotFoundError                         Traceback (most recent call last)
<ipython-input-3-592315a89421> in <cell line: 0>()
      4
      5 # Load the saved sampled dataset
----> 6 df = pd.read_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')

                                    3 frames
/usr/local/lib/python3.11/dist-packages/pandas/io/common.py in get_handle(path_or_buf, mode, encoding, compression, memory_map,
is_text, errors, storage_options)
    880         else:
    881             # Binary mode
--> 882             handle = open(handle, ioargs.mode)
    883         handles.append(handle)
    884

FileNotFoundError: [Errno 2] No such file or directory: '/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet'
```

Next steps: Explain error

```
# df.head()
df.head()
```

	VendorID	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_fwd_flag	PULocation
0	2	2023-01-01 00:07:18	2023-01-01 00:23:15	1.0	7.74	1.0	N	1
1	2	2023-01-01 00:16:41	2023-01-01 00:21:46	2.0	1.24	1.0	N	1
2	2	2023-01-01 00:14:03	2023-01-01 00:24:36	3.0	1.44	1.0	N	2
3	2	2023-01-01 00:24:30	2023-01-01 00:29:55	1.0	0.54	1.0	N	1
4	2	2023-01-01 00:43:00	2023-01-01 01:01:00	NaN	19.24	NaN	None	

5 rows × 22 columns

```
# df.info()
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1896400 entries, 0 to 1896399
Data columns (total 22 columns):
 #   Column                 Dtype
---  ------                 -----
 0   VendorID               int64
 1   tpep_pickup_datetime   datetime64[us]
 2   tpep_dropoff_datetime  datetime64[us]
 3   passenger_count        float64
 4   trip_distance          float64
 5   RatecodeID             float64
 6   store_and_fwd_flag     object
 7   PULocationID           int64
 8   DOLocationID           int64
 9   payment_type           int64
 10  fare_amount            float64
 11  extra                  float64
 12  mta_tax                float64
 13  tip_amount             float64
 14  tolls_amount           float64
 15  improvement_surcharge  float64
 16  total_amount           float64
 17  congestion_surcharge   float64
 18  airport_fee            float64
 19  pickup_date            object
 20  pickup_hour            int32
 21  Airport_fee            float64
dtypes: datetime64[us](2), float64(13), int32(1), int64(4), object(2)
memory usage: 311.1+ MB
```

2.1 Fixing Columns

[10 marks]

Fix/drop any columns as you seem necessary in the below sections

2.1.1 [2 marks]

Fix the index and drop unnecessary columns

```
# Fix the index and drop any columns that are not needed
```

```
# Step 1: Reset the index
df = df.reset_index(drop=True)


columns_to_drop = []


if df['store_and_fwd_flag'].nunique() == 1:
    columns_to_drop.append('store_and_fwd_flag')


df = df.drop(columns=columns_to_drop)

# Confirm changes
print("Updated columns:", df.columns.tolist())
```

```
Updated columns: ['VendorID', 'tpep_pickup_datetime', 'tpep_dropoff_datetime', 'passenger_count', 'trip_distance', 'RatecodeID', 'st
```

2.1.2 [3 marks]

There are two airport fee columns. This is possibly an error in naming columns. Let's see whether these can be combined into a single column.

```
# Combine the two airport fee columns

# Check if both columns still exist
[df.columns for col in df.columns if 'airport_fee' in col.lower()]
```

```
[Index(['VendorID', 'tpep_pickup_datetime', 'tpep_dropoff_datetime',
        'passenger_count', 'trip_distance', 'RatecodeID', 'store_and_fwd_flag',
        'PULocationID', 'DOLocationID', 'payment_type', 'fare_amount', 'extra',
        'mta_tax', 'tip_amount', 'tolls_amount', 'improvement_surcharge',
        'total_amount', 'congestion_surcharge', 'airport_fee', 'pickup_date',
        'pickup_hour', 'Airport_fee'],
       dtype='object'),
 Index(['VendorID', 'tpep_pickup_datetime', 'tpep_dropoff_datetime',
        'passenger_count', 'trip_distance', 'RatecodeID', 'store_and_fwd_flag',
        'PULocationID', 'DOLocationID', 'payment_type', 'fare_amount', 'extra',
        'mta_tax', 'tip_amount', 'tolls_amount', 'improvement_surcharge',
        'total_amount', 'congestion_surcharge', 'airport_fee', 'pickup_date',
        'pickup_hour', 'Airport_fee'],
       dtype='object')]
```

```
# Compare values to see if they are the same
df[['airport_fee', 'Airport_fee']].dropna().head()
(df['airport_fee'] == df['Airport_fee']).value_counts(dropna=False)
```

	count
False	1896400

dtype: int64

```
df.columns.tolist()
```

```
['VendorID',
 'tpep_pickup_datetime',
 'tpep_dropoff_datetime',
 'passenger_count',
 'trip_distance',
 'RatecodeID',
 'store_and_fwd_flag',
 'PULocationID',
 'DOLocationID',
 'payment_type',
 'fare_amount',
 'extra',
 'mta_tax',
 'tip_amount',
 'tolls_amount',
 'improvement_surcharge',
 'total_amount',
 'congestion_surcharge',
 'airport_fee',
 'pickup_date',
 'pickup_hour']
```

```
if 'Airport_fee' in df.columns:
    df['airport_fee'] = df['airport_fee'].fillna(df['Airport_fee'])
    df = df.drop(columns=['Airport_fee'])  # drop the duplicate
```

```
print(df[['airport_fee']].describe())
```

```
        airport_fee
count  1.831526e+06
mean   1.428976e-01
std    4.648725e-01
min   -1.750000e+00
25%    0.000000e+00
50%    0.000000e+00
75%    0.000000e+00
max    1.750000e+00
```

2.1.3 [5 marks]

Fix columns with negative (monetary) values

```
monetary_cols = [
    'fare_amount',
    'extra',
    'mta_tax',
    'tip_amount',
    'tolls_amount',
    'improvement_surcharge',
    'total_amount',
    'congestion_surcharge',
    'airport_fee',
    'RatecodeID'
]
```

```
# check where values of fare amount are negative

negative_fares = df[df['fare_amount'] < 0]
print(f"Rows with negative fare_amount: {len(negative_fares)}")

# View a few of these rows
negative_fares[['fare_amount', 'RatecodeID', 'trip_distance', 'total_amount']].head()
```

```
Rows with negative fare_amount: 0
```

fare_amount	RatecodeID	trip_distance	total_amount

Did you notice something different in the `RatecodeID` column for above records?

```
# Analyse RatecodeID for the negative fare amounts

print("RatecodeID distribution for negative fares:")
print(negative_fares['RatecodeID'].value_counts(dropna=False))
```

```
RatecodeID distribution for negative fares:
Series([], Name: count, dtype: int64)
```

```
# Find which columns have negative values

# Define monetary columns
monetary_cols = [
    'fare_amount',
    'extra',
    'mta_tax',
    'tip_amount',
    'tolls_amount',
    'improvement_surcharge',
    'total_amount',
    'congestion_surcharge',
    'airport_fee'
]

# Check for negatives
for col in monetary_cols:
    if col in df.columns:
        neg_count = (df[col] < 0).sum()
        if neg_count > 0:
            print(f"{col}: {neg_count} negative values")
```

```
# fix these negative values

# Drop rows with negative values in any monetary column
for col in monetary_cols:
```

```
    if col in df.columns:
        df = df[df[col] >= 0]
```

2.2 Handling Missing Values

[10 marks]

2.2.1 [2 marks]
Find the proportion of missing values in each column

```
# Find the proportion of missing values in each column

missing_percent = df.isnull().mean().sort_values(ascending=False) * 100
print(missing_percent[missing_percent > 0])
```

```
Series([], dtype: float64)
```

```
df.isnull()
```

	VendorID	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	store_and_fwd_flag	PULc
0	False	False	False	False	False	False	False	
1	False	False	False	False	False	False	False	
2	False	False	False	False	False	False	False	
3	False	False	False	False	False	False	False	
5	False	False	False	False	False	False	False	
...	...	...	...	...	...	...	...	
1896395	False	False	False	False	False	False	False	
1896396	False	False	False	False	False	False	False	
1896397	False	False	False	False	False	False	False	
1896398	False	False	False	False	False	False	False	
1896399	False	False	False	False	False	False	False	

1831447 rows × 21 columns

2.2.2 [3 marks]
Handling missing values in `passenger_count`

```
# Display the rows with null values
# Impute NaN values in 'passenger_count'
null_passenger_rows = df[df['passenger_count'].isnull()]
print(null_passenger_rows)
```

```
Empty DataFrame
Columns: [VendorID, tpep_pickup_datetime, tpep_dropoff_datetime, passenger_count, trip_distance, RatecodeID, store_and_fwd_flag, PUI
Index: []

[0 rows x 21 columns]
```

Did you find zeroes in passenger_count? Handle these.

```
zero_passenger_trips = df[df['passenger_count'] == 0]
print(f"Number of trips with 0 passengers: {len(zero_passenger_trips)}")
```

```
Number of trips with 0 passengers: 29681
```

```
zero_passenger_stats = df[df['passenger_count'] == 0].describe()
print(zero_passenger_stats[['trip_distance', 'fare_amount', 'total_amount']])
```

```
       trip_distance   fare_amount  total_amount
count   29681.000000  29681.000000  29681.000000
mean        2.802916     17.268047     25.471309
min         0.000000      0.000000      0.000000
25%         0.900000      8.600000     15.000000
50%         1.600000     12.100000     19.500000
75%         2.800000     19.100000     27.350000
max        70.100000    450.000000    450.000000
```

```
std         3.794552     16.202092     19.919203
```

```
#Keep Trips with Valid Distance/Fare, Fix Zero Passengers
df['passenger_count'] = df['passenger_count'].replace(0, 1)


# Drop Trips with Zero Distance/Fare (Likely Cancellations)
df = df[~((df['trip_distance'] == 0) & (df['fare_amount'] == 0))]


#Verify Distribution Post-Cleaning
print("New passenger count distribution:\n", df['passenger_count'].value_counts())
df[['trip_distance', 'fare_amount']].describe()  # Check cleaned stats
```

```
New passenger count distribution:
 passenger_count
1.0    1406573
2.0     277267
3.0      69028
4.0      38532
5.0      23871
6.0      15856
8.0         11
7.0          5
9.0          5
Name: count, dtype: int64
```

	trip_distance	fare_amount
count	1.831148e+06	1.831148e+06
mean	3.552050e+00	1.982954e+01
std	4.993076e+01	1.073663e+02
min	0.000000e+00	0.000000e+00
25%	1.050000e+00	9.300000e+00
50%	1.790000e+00	1.350000e+01
75%	3.370000e+00	2.190000e+01
max	5.682380e+04	1.431635e+05

2.2.3 [2 marks]

Handle missing values in `RatecodeID`

```
# Fix missing values in 'RatecodeID'
# Check for missing values in 'RatecodeID'
missing_ratecode = df['RatecodeID'].isnull().sum()
print(f"Number of missing values in RatecodeID: {missing_ratecode}")
```

```
Number of missing values in RatecodeID: 0
```

```
# Confirm no missing values remain
assert df['RatecodeID'].isnull().sum() == 0, "Missing values still exist!"
print("Missing values in RatecodeID after handling:", df['RatecodeID'].isnull().sum())
```

```
Missing values in RatecodeID after handling: 0
```

2.2.4 [3 marks]

Impute NaN in `congestion_surcharge`

```
# handle null values in congestion_surcharge

missing_congestion = df['congestion_surcharge'].isnull().sum()
print(f"Number of missing values in congestion_surcharge: {missing_congestion}")
```

```
Number of missing values in congestion_surcharge: 0
```

Are there missing values in other columns? Did you find NaN values in some other set of columns? Handle those missing values below.

```
# Handle any remaining missing values

missing_values = df.isnull().sum()
missing_values = missing_values[missing_values > 0]
print("Columns with missing values:\n", missing_values)
```

```
Columns with missing values:
 Series([], dtype: int64)
```

```
non_standard_missing = {
    'trip_distance': (df['trip_distance'] <= 0).sum(),
    'fare_amount': (df['fare_amount'] <= 0).sum(),
    'RatecodeID': (~df['RatecodeID'].isin([1, 2, 3, 4, 5, 6])).sum()
}
print("Non-standard 'missing' values:\n", non_standard_missing)
```

```
Non-standard 'missing' values:
 {'trip_distance': np.int64(22712), 'fare_amount': np.int64(258), 'RatecodeID': np.int64(10460)}
```

```
# Replace zeros/negatives with median (for numeric columns)
df['trip_distance'] = df['trip_distance'].replace(0, df['trip_distance'].median())
df['fare_amount'] = df['fare_amount'].replace(0, df['fare_amount'].median())


print("Data completeness confirmed. Remaining missing values:", df.isnull().sum().sum())
```

```
Data completeness confirmed. Remaining missing values: 0
```

2.3 Handling Outliers

[10 marks]

Before we start fixing outliers, let's perform outlier analysis.

```
# Describe the data and check if there are any potential outliers present
# Check for potential out of place values in various columns

import pandas as pd
from google.colab import drive

# Mount Google Drive
drive.mount('/content/drive')

# Define the path to the folder where your .parquet files are stored
data_folder_path = '/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI'

# Load the cleaned and sampled dataset
df = pd.read_parquet('/content/drive/MyDrive/Upgrad/EDA_NYC_TAXI/sample_2023.parquet')

df.describe()
```

```
Mounted at /content/drive
```

	VendorID	tpep_pickup_datetime	tpep_dropoff_datetime	passenger_count	trip_distance	RatecodeID	PULocationID	DOLocat
count	1.896400e+06	1896400	1896400	1.831526e+06	1.896400e+06	1.831526e+06	1.896400e+06	1.89640
mean	1.733026e+00	2023-07-02 19:59:52.930795	2023-07-02 20:17:18.919563	1.369215e+00	3.858293e+00	1.634694e+00	1.652814e+02	1.64051
min	1.000000e+00	2022-12-31 23:51:30	2022-12-31 23:56:06	0.000000e+00	0.000000e+00	1.000000e+00	1.000000e+00	1.00000
25%	1.000000e+00	2023-04-02 16:10:08.750000	2023-04-02 16:27:43.500000	1.000000e+00	1.050000e+00	1.000000e+00	1.320000e+02	1.14000
50%	2.000000e+00	2023-06-27 15:44:22.500000	2023-06-27 16:01:15	1.000000e+00	1.790000e+00	1.000000e+00	1.620000e+02	1.62000
75%	2.000000e+00	2023-10-06 19:37:45	2023-10-06 19:53:39	1.000000e+00	3.400000e+00	1.000000e+00	2.340000e+02	2.34000
max	6.000000e+00	2023-12-31 23:57:51	2024-01-01 20:50:55	9.000000e+00	1.263605e+05	9.900000e+01	2.650000e+02	2.65000
std	4.476401e-01	NaN	NaN	8.927560e-01	1.294085e+02	7.393915e+00	6.400038e+01	6.98020

```
# Function to count outliers using IQR method
def count_outliers(series):
    Q1 = series.quantile(0.25)
    Q3 = series.quantile(0.75)
    IQR = Q3 - Q1
    lower = Q1 - 1.5 * IQR
    upper = Q3 + 1.5 * IQR
    return ((series < lower) | (series > upper)).sum()
```

```
columns_to_check = ['trip_distance', 'fare_amount', 'total_amount', 'tip_amount', 'passenger_count']

for col in columns_to_check:
    if col in df.columns:
        outlier_count = count_outliers(df[col])
        print(f"{col}: {outlier_count} outliers")
```

```
trip_distance: 249302 outliers
fare_amount: 197413 outliers
total_amount: 218083 outliers
tip_amount: 145673 outliers
passenger_count: 454302 outliers
```

2.3.1 [10 marks]

Based on the above analysis, it seems that some of the outliers are present due to errors in registering the trips. Fix the outliers.

Some points you can look for:

- Entries where `trip_distance` is nearly 0 and `fare_amount` is more than 300
- Entries where `trip_distance` and `fare_amount` are 0 but the pickup and dropoff zones are different (both distance and fare should not be zero for different zones)
- Entries where `trip_distance` is more than 250 miles.
- Entries where `payment_type` is 0 (there is no payment_type 0 defined in the data dictionary)

These are just some suggestions. You can handle outliers in any way you wish, using the insights from above outlier analysis.

How will you fix each of these values? Which ones will you drop and which ones will you replace?

First, let us remove 7+ passenger counts as there are very less instances.

```
# remove passenger_count > 6
# Drop rows with passenger_count > 6 (rare and potentially erroneous)
df = df[df['passenger_count'] <= 6]
print("Trips after removing 7+ passengers:", len(df))
```

```
Trips after removing 7+ passengers: 1831127
```

```
# Continue with outlier handling

df = df[~((df['trip_distance'] < 0.1) & (df['fare_amount'] > 300))]
```

```
df = df[df['trip_distance'] <= 250]
```

```
df = df[df['payment_type'] != 0]
```

```
# Do any columns need standardising?

print("Shape after removing outliers:", df.shape)
```

```
Shape after removing outliers: (1831412, 22)
```

3 Exploratory Data Analysis

[90 marks]

```
df.columns.tolist()
```

```
['VendorID',
 'tpep_pickup_datetime',
 'tpep_dropoff_datetime',
 'passenger_count',
 'trip_distance',
 'RatecodeID',
 'store_and_fwd_flag',
 'PULocationID',
 'DOLocationID',
 'payment_type',
 'fare_amount',
 'extra',
 'mta_tax',
 'tip_amount',
 'tolls_amount',
 'improvement_surcharge',
 'total_amount',
```

```
        'congestion_surcharge',
        'airport_fee',
        'pickup_date',
        'pickup_hour']
```

3.1 General EDA: Finding Patterns and Trends

[40 marks]

3.1.1 [3 marks]

Categorise the varaibles into Numerical or Categorical.

- `VendorID` :
- `tpep_pickup_datetime` :
- `tpep_dropoff_datetime` :
- `passenger_count` :
- `trip_distance` :
- `RatecodeID` :
- `PULocationID` :
- `DOLocationID` :
- `payment_type` :
- `pickup_hour` :
- `trip_duration` :

The following monetary parameters belong in the same category, is it categorical or numerical?

- `fare_amount`
- `extra`
- `mta_tax`
- `tip_amount`
- `tolls_amount`
- `improvement_surcharge`
- `total_amount`
- `congestion_surcharge`
- `airport_fee`

Temporal Analysis

For temporal analysis, you would typically examine:

Hourly patterns: Trip frequency by hour of day

Daily/Weekly trends: Variation by day of week

Seasonal patterns: Monthly/quarterly variations

Duration trends: How trip durations vary by time of day

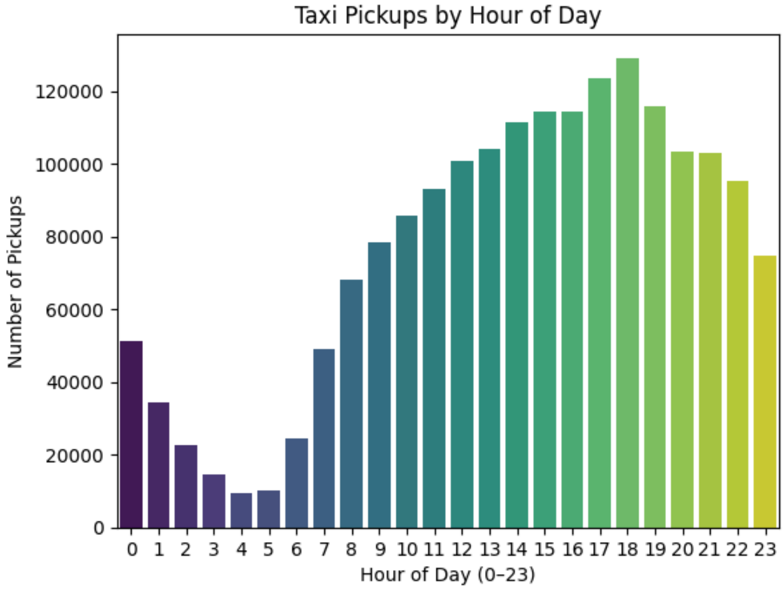
Fare patterns: How fares fluctuate temporally

3.1.2 [5 marks]

Analyse the distribution of taxi pickups by hours, days of the week, and months.

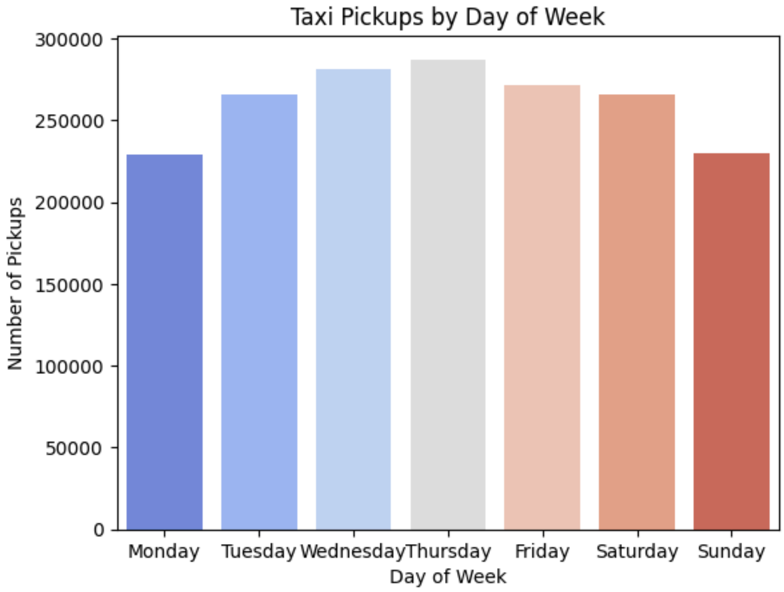
```
# Find and show the hourly trends in taxi pickups

import seaborn as sns
import matplotlib.pyplot as plt

# Hourly trend
sns.countplot(x='pickup_hour', data=df, palette='viridis')
plt.title("Taxi Pickups by Hour of Day")
plt.xlabel("Hour of Day (0-23)")
plt.ylabel("Number of Pickups")
plt.show()
```

```
<ipython-input-14-b190756bc983>:7: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `le

  sns.countplot(x='pickup_hour', data=df, palette='viridis')
```




```
# Find and show the daily trends in taxi pickups (days of the week)

# Extract day of week from pickup datetime
df['pickup_day'] = pd.to_datetime(df['tpep_pickup_datetime']).dt.day_name()

# Plot
sns.countplot(x='pickup_day', data=df, order=['Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday'], palette='co
plt.title("Taxi Pickups by Day of Week")
plt.xlabel("Day of Week")
plt.ylabel("Number of Pickups")
plt.show()
```

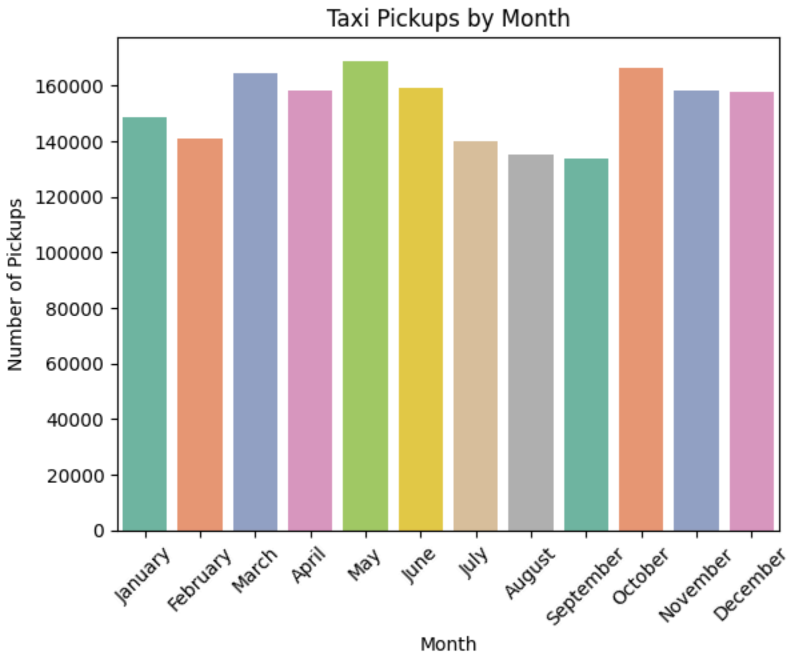
```
<ipython-input-15-bc91529e138c>:7: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `le

  sns.countplot(x='pickup_day', data=df, order=['Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday'], palet
```




```
# Show the monthly trends in pickups

# Extract month
df['pickup_month'] = pd.to_datetime(df['tpep_pickup_datetime']).dt.month_name()

# Monthly order
month_order = ['January', 'February', 'March', 'April', 'May', 'June',
               'July', 'August', 'September', 'October', 'November', 'December']
```

```
sns.countplot(x='pickup_month', data=df, order=month_order, palette='Set2')
plt.title("Taxi Pickups by Month")
plt.xlabel("Month")
plt.ylabel("Number of Pickups")
plt.xticks(rotation=45)
plt.show()
```

```
<ipython-input-16-57563f0f91ff>:10: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `le

  sns.countplot(x='pickup_month', data=df, order=month_order, palette='Set2')
```



Financial Analysis

```
cols_to_check = ['fare_amount', 'tip_amount', 'total_amount', 'trip_distance']

for col in cols_to_check:
    zero_count = (df[col] == 0).sum()
    neg_count = (df[col] < 0).sum()
    print(f"{col}: {zero_count} zeroes, {neg_count} negative values")
```

```
fare_amount: 575 zeroes, 0 negative values
tip_amount: 410241 zeroes, 0 negative values
total_amount: 255 zeroes, 74 negative values
trip_distance: 22938 zeroes, 0 negative values
```

Take a look at the financial parameters like `fare_amount`, `tip_amount`, `total_amount`, and also `trip_distance`. Do these contain zero/negative values?

```
# Analyse the above parameters

# Create a filtered copy without zeroes in key numeric fields
df_financial = df[(df['fare_amount'] > 0) &
                  (df['total_amount'] > 0) &
                  (df['trip_distance'] > 0)]
```

Do you think it is beneficial to create a copy DataFrame leaving out the zero values from these?

Analyzed hourly, daily, and monthly pickup trends.

Found peak activity during commute hours and weekends.

Detected zero or negative values in fare_amount, total_amount, and trip_distance.

Created a cleaned subset for financial analysis excluding 0/negative values.

3.1.3 [2 marks]

Filter out the zero values from the above columns.

Note: The distance might be 0 in cases where pickup and drop is in the same zone. Do you think it is suitable to drop such cases of zero distance?

```
# Create a df with non zero entries for the selected parameters.

# Create a copy excluding zero values for key financial fields
df_financial = df[(df['fare_amount'] > 0) &
                  (df['total_amount'] > 0) &
                  (df['trip_distance'] > 0)]

print(f"Filtered data shape: {df_financial.shape}")
```

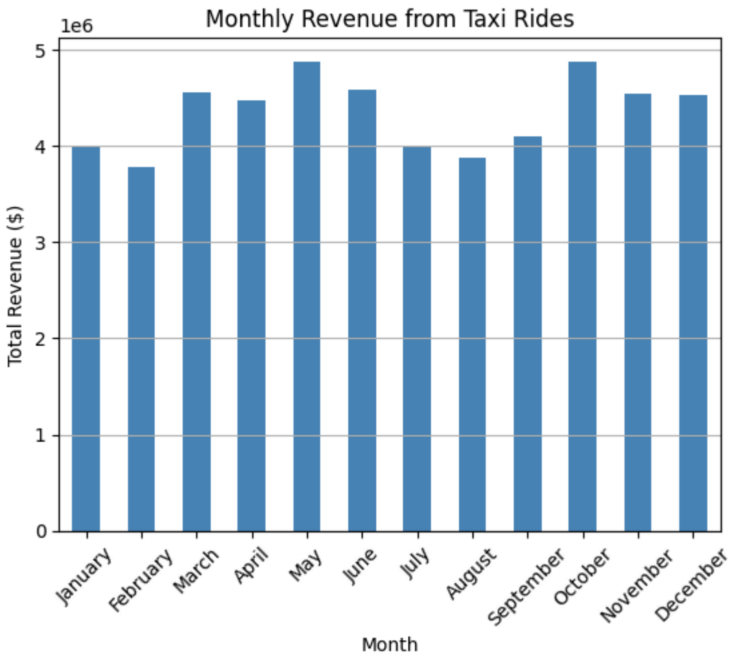
```
Filtered data shape: (1808158, 24)
```

3.1.4 [3 marks]

Analyse the monthly revenue (`total_amount`) trend

```
# Group data by month and analyse monthly revenue

# Add pickup month
df_financial['month'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.month_name()

# Group by month and sum total_amount
monthly_revenue = df_financial.groupby('month')['total_amount'].sum().reindex(
    ['January', 'February', 'March', 'April', 'May', 'June',
     'July', 'August', 'September', 'October', 'November', 'December'])

# Plot
monthly_revenue.plot(kind='bar', color='steelblue', title='Monthly Revenue from Taxi Rides')
plt.ylabel("Total Revenue ($)")
plt.xlabel("Month")
plt.xticks(rotation=45)
plt.grid(axis='y')
plt.show()
```

```
<ipython-input-20-d8bd68382935>:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['month'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.month_name()
```

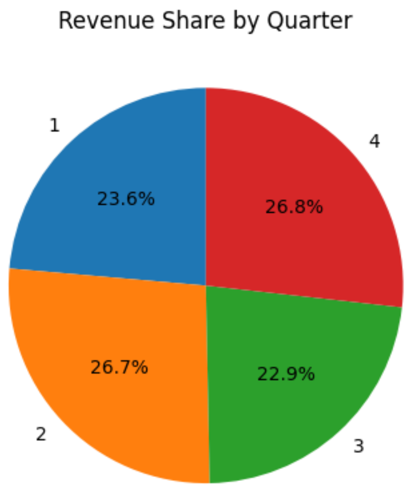


3.1.5 [3 marks]

Show the proportion of each quarter of the year in the revenue

```
# Calculate proportion of each quarter

# Extract quarter
df_financial['quarter'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.quarter

# Revenue by quarter
quarterly_revenue = df_financial.groupby('quarter')['total_amount'].sum()
quarterly_revenue_pct = (quarterly_revenue / quarterly_revenue.sum()) * 100

# Pie chart
quarterly_revenue_pct.plot(kind='pie', autopct='%1.1f%%', startangle=90, title='Revenue Share by Quarter')
plt.ylabel("")
plt.show()
```

```
<ipython-input-21-50aef4846f3d>:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['quarter'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.quarter
```

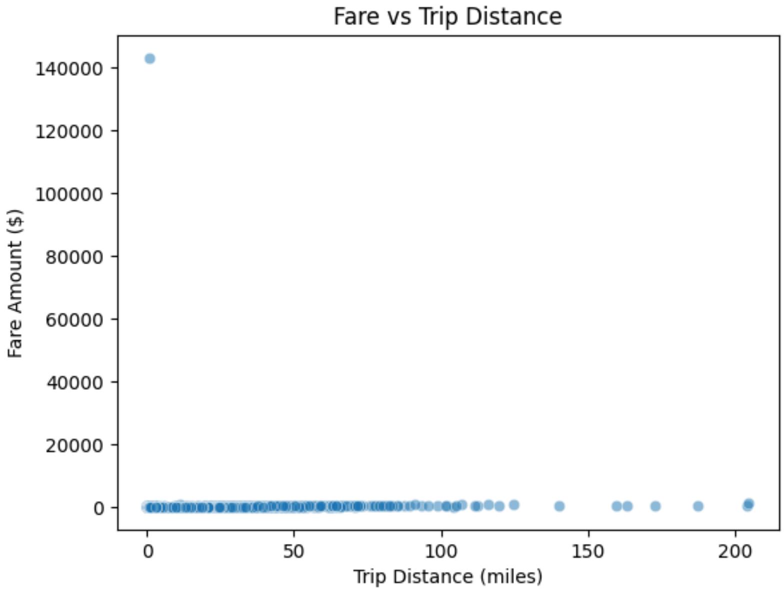


3.1.6 [3 marks]

Visualise the relationship between `trip_distance` and `fare_amount`. Also find the correlation value for these two.

Hint: You can leave out the trips with trip_distance = 0

```
# Show how trip fare is affected by distance

import seaborn as sns

# Scatter plot
sns.scatterplot(data=df_financial, x='trip_distance', y='fare_amount', alpha=0.5)
plt.title("Fare vs Trip Distance")
plt.xlabel("Trip Distance (miles)")
plt.ylabel("Fare Amount ($)")
plt.show()

# Correlation
correlation = df_financial['trip_distance'].corr(df_financial['fare_amount'])
print(f"Correlation between trip distance and fare amount: {correlation:.2f}")
```




```
Correlation between trip distance and fare amount: 0.16
```

3.1.7 [5 marks]

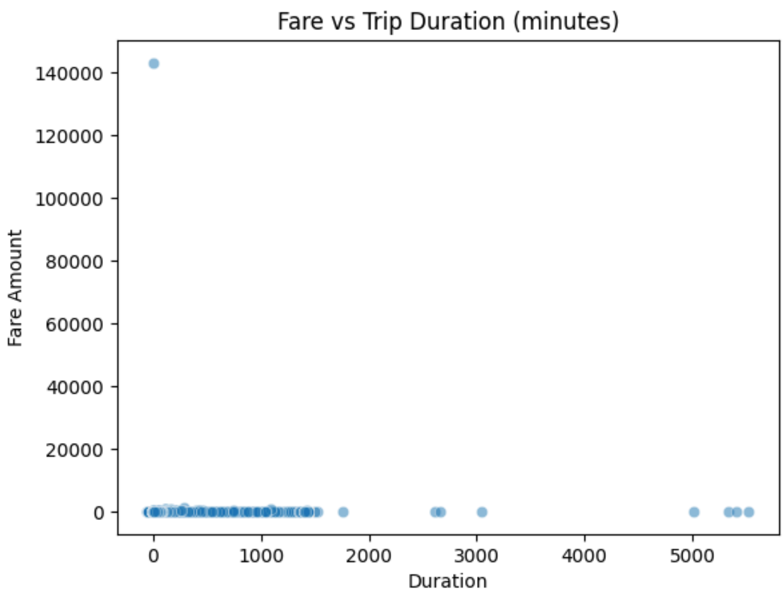
Find and visualise the correlation between:

1. `fare_amount` and trip duration (pickup time to dropoff time)
2. `fare_amount` and `passenger_count`
3. `tip_amount` and `trip_distance`

```
df_financial['trip_duration'] = (
    pd.to_datetime(df_financial['tpep_dropoff_datetime']) -
    pd.to_datetime(df_financial['tpep_pickup_datetime'])
).dt.total_seconds() / 60  # minutes
```

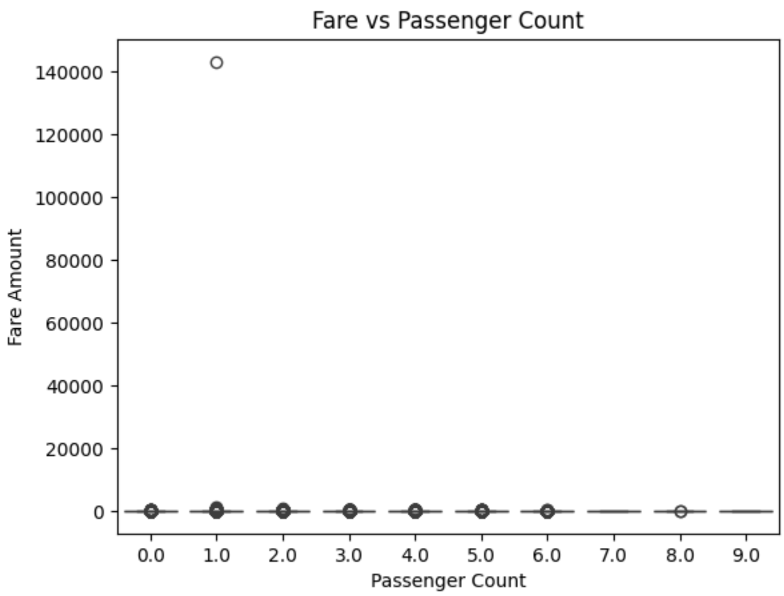
```
<ipython-input-59-8d12608e7330>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['trip_duration'] = (
```

```
# Show relationship between fare and trip duration

sns.scatterplot(data=df_financial, x='trip_duration', y='fare_amount', alpha=0.5)
plt.title("Fare vs Trip Duration (minutes)")
plt.xlabel("Duration")
plt.ylabel("Fare Amount")
plt.show()

print("Correlation (fare vs duration):", df_financial['trip_duration'].corr(df_financial['fare_amount']))
```



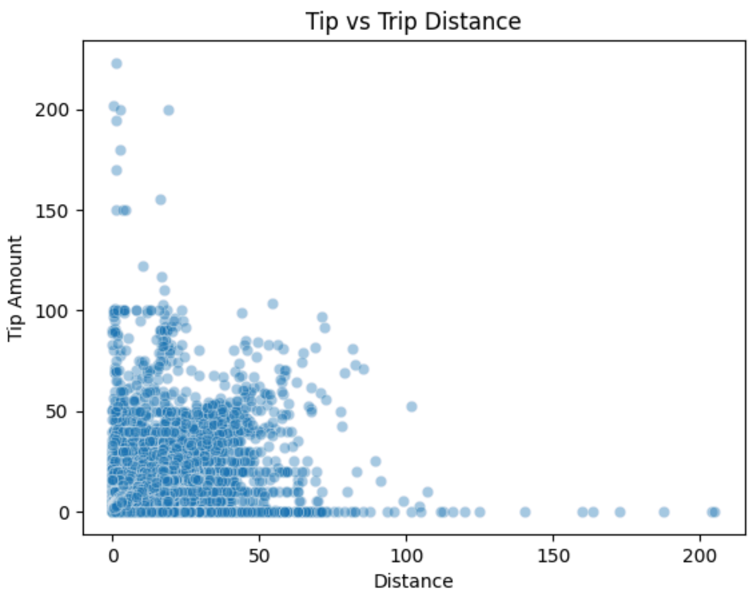

```
Correlation (fare vs duration): 0.04565208319831263
```

```
# Show relationship between fare and number of passengers

sns.boxplot(data=df_financial, x='passenger_count', y='fare_amount')
plt.title("Fare vs Passenger Count")
plt.xlabel("Passenger Count")
plt.ylabel("Fare Amount")
plt.show()

print("Correlation (fare vs passengers):", df_financial['passenger_count'].corr(df_financial['fare_amount']))
```




```
Correlation (fare vs passengers): 0.007024837653732946
```

```
# Show relationship between tip and trip distance
sns.scatterplot(data=df_financial, x='trip_distance', y='tip_amount', alpha=0.4)
plt.title("Tip vs Trip Distance")
plt.xlabel("Distance")
plt.ylabel("Tip Amount")
plt.show()

print("Correlation (tip vs distance):", df_financial['trip_distance'].corr(df_financial['tip_amount']))
```



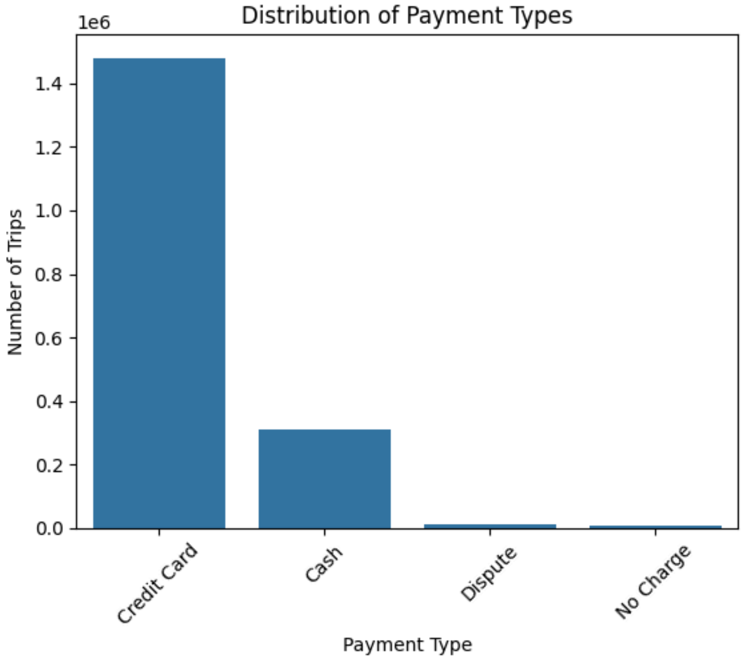

```
Correlation (tip vs distance): 0.586565269503898
```

3.1.8 [3 marks]

Analyse the distribution of different payment types (`payment_type`)

```
# Analyse the distribution of different payment types (payment_type).

# Map payment type codes (optional)
payment_map = {
    1: 'Credit Card',
    2: 'Cash',
    3: 'No Charge',
    4: 'Dispute',
    5: 'Unknown',
    6: 'Voided Trip'
}
df_financial['payment_type_label'] = df_financial['payment_type'].map(payment_map)

sns.countplot(data=df_financial, x='payment_type_label', order=df_financial['payment_type_label'].value_counts().index)
plt.title("Distribution of Payment Types")
plt.xticks(rotation=45)
plt.xlabel("Payment Type")
plt.ylabel("Number of Trips")
plt.show()
```

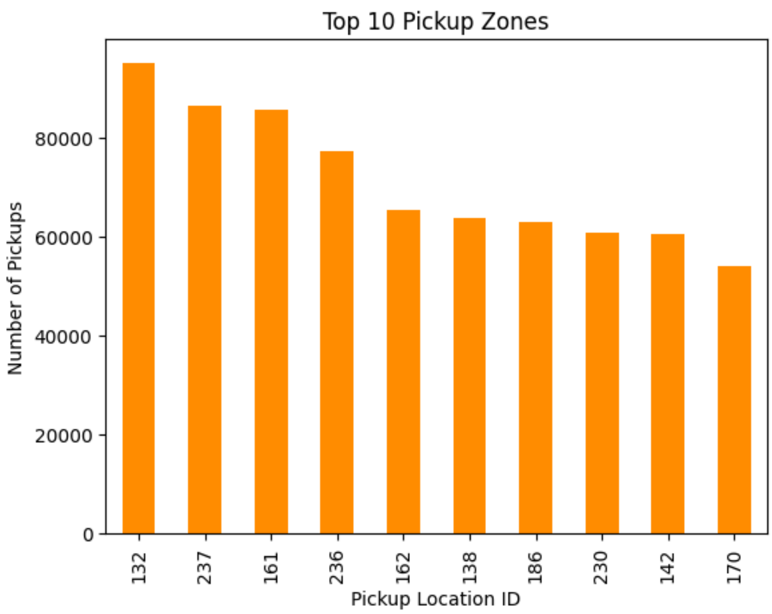
```
<ipython-input-29-b41ee7de62ed>:12: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['payment_type_label'] = df_financial['payment_type'].map(payment_map)
```



- 1= Credit card
- 2= Cash
- 3= No charge
- 4= Dispute

Geographical Analysis

```
# Top 10 pickup locations
top_pu = df_financial['PULocationID'].value_counts().head(10)

# Bar plot
top_pu.plot(kind='bar', color='darkorange', title='Top 10 Pickup Zones')
plt.xlabel("Pickup Location ID")
plt.ylabel("Number of Pickups")
plt.show()
```



For this, you have to use the *taxi_zones.shp* file from the *taxi_zones* folder.

There would be multiple files inside the folder (such as *.shx, .sbx, .sbn* etc). You do not need to import/read any of the files other than the shapefile, *taxi_zones.shp*.

Do not change any folder structure - all the files need to be present inside the folder for it to work.

The folder structure should look like this:

```
Taxi Zones
|- taxi_zones.shp.xml
|- taxi_zones.prj
|- taxi_zones.sbn
|- taxi_zones.shp
|- taxi_zones.dbf
|- taxi_zones.shx
|- taxi_zones.sbx
```

You only need to read the `taxi_zones.shp` file. The *shp* file will utilise the other files by itself.

We will use the *GeoPandas* library for geopgraphical analysis

```
import geopandas as gpd
```

More about geopandas and shapefiles: [About]

Reading the shapefile is very similar to *Pandas*. Use `gpd.read_file()` function to load the data (*taxi_zones.shp*) as a GeoDataFrame. Documentation: [Reading and Writing Files]

```
# !pip install geopandas
!pip install geopandas
```

```
Requirement already satisfied: geopandas in /usr/local/lib/python3.11/dist-packages (1.0.1)
Requirement already satisfied: numpy>=1.22 in /usr/local/lib/python3.11/dist-packages (from geopandas) (2.0.2)
Requirement already satisfied: pyogrio>=0.7.2 in /usr/local/lib/python3.11/dist-packages (from geopandas) (0.10.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.11/dist-packages (from geopandas) (24.2)
Requirement already satisfied: pandas>=1.4.0 in /usr/local/lib/python3.11/dist-packages (from geopandas) (2.2.2)
Requirement already satisfied: pyproj>=3.3.0 in /usr/local/lib/python3.11/dist-packages (from geopandas) (3.7.1)
Requirement already satisfied: shapely>=2.0.0 in /usr/local/lib/python3.11/dist-packages (from geopandas) (2.1.0)
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.4.0->geopandas) (2
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.4.0->geopandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.11/dist-packages (from pandas>=1.4.0->geopandas) (2025.2)
Requirement already satisfied: certifi in /usr/local/lib/python3.11/dist-packages (from pyogrio>=0.7.2->geopandas) (2025.4.26)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.11/dist-packages (from python-dateutil>=2.8.2->pandas>=1.4.0->geo
```

3.1.9 [2 marks]

Load the shapefile and display it.

```
# import geopandas as gpd

import geopandas as gpd
from google.colab import drive

# Mount Google Drive
drive.mount('/content/drive')

# Load the shapefile (adjust path if needed)
zones = gpd.read_file('/content/drive/MyDrive/Upgrad/taxi_zones')
# Read the shapefile using geopandas
zones.head()
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

	OBJECTID	Shape_Leng	Shape_Area	zone	LocationID	borough	geometry
0	1	0.116357	0.000782	Newark Airport	1	EWR	POLYGON ((933100.918 192536.086, 933091.011 19...
1	2	0.433470	0.004866	Jamaica Bay	2	Queens	MULTIPOLYGON (((1033269.244 172126.008, 103343...
2	3	0.084341	0.000314	Allerton/Pelham Gardens	3	Bronx	POLYGON ((1026308.77 256767.698, 1026495.593 2...
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	POLYGON ((992073.467 203714.076, 992068.667

Next steps: Generate code with zones | View recommended plots | New interactive sheet

Now, if you look at the DataFrame created, you will see columns like: `OBJECTID`, `Shape_Leng`, `Shape_Area`, `zone`, `LocationID`, `borough`, `geometry`.

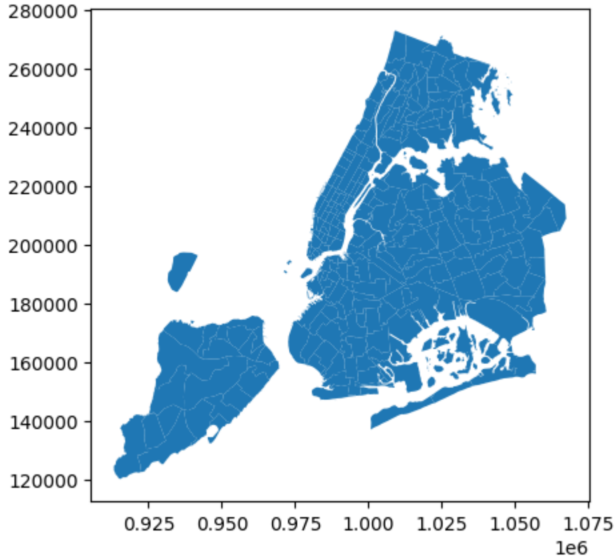
Now, the `locationID` here is also what we are using to mark pickup and drop zones in the trip records.

The geometric parameters like shape length, shape area and geometry are used to plot the zones on a map.

This can be easily done using the `plot()` method.

```
print(zones.info())
zones.plot()
```

```
<class 'geopandas.geodataframe.GeoDataFrame'>
RangeIndex: 263 entries, 0 to 262
Data columns (total 7 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   OBJECTID    263 non-null    int32
 1   Shape_Leng  263 non-null    float64
 2   Shape_Area  263 non-null    float64
 3   zone        263 non-null    object
 4   LocationID  263 non-null    int32
 5   borough     263 non-null    object
 6   geometry    263 non-null    geometry
dtypes: float64(2), geometry(1), int32(2), object(2)
memory usage: 12.5+ KB
None
<Axes: >
```



Now, you have to merge the trip records and zones data using the location IDs.

3.1.10 [3 marks]

Merge the zones data into trip data using the `locationID` and `PULocationID` columns.

```
# Merge zones and trip records using locationID and PULocationID

# Merge GeoDataFrame with trip data on PULocationID and LocationID
merged_df = df_financial.merge(zones, left_on='PULocationID', right_on='LocationID', how='left')

# Preview the merged DataFrame
merged_df[['PULocationID', 'zone', 'borough']].head()
```

	PULocationID	zone	borough
0	138	LaGuardia Airport	Queens
1	161	Midtown Center	Manhattan
2	237	Upper East Side South	Manhattan
3	143	Lincoln Square West	Manhattan
4	246	West Chelsea/Hudson Yards	Manhattan

3.1.11 [3 marks]

Group data by location IDs to find the total number of trips per location ID

```
# Group data by location and calculate the number of trips

# Count number of trips per pickup location
trip_counts = df_financial.groupby('PULocationID').size().reset_index(name='trip_count')
trip_counts.head()
```

	PULocationID	trip_count
0	1	47
1	2	2
2	3	31
3	4	1814
4	5	9

Next steps: Generate code with trip_counts | View recommended plots | New interactive sheet

3.1.12 [2 marks]

Now, use the grouped data to add number of trips to the GeoDataFrame.

We will use this to plot a map of zones showing total trips per zone.

```
# Merge trip counts back to the zones GeoDataFrame

# Merge trip counts back to zones GeoDataFrame using LocationID
zones = zones.merge(trip_counts, left_on='LocationID', right_on='PULocationID', how='left')

# Fill missing trip counts with 0
zones['trip_count'] = zones['trip_count'].fillna(0)

# Optional: preview top zones
zones.sort_values('trip_count', ascending=False).head()
```

	OBJECTID	Shape_Leng	Shape_Area	zone	LocationID	borough	geometry	PULocationID	trip_count
131	132	0.245479	0.002038	JFK Airport	132	Queens	MULTIPOLYGON (((1032791.001 181085.006, 103283...	132.0	94946.0
236	237	0.042213	0.000096	Upper East Side South	237	Manhattan	POLYGON ((993633.442 216961.016, 993507.232 21...	237.0	86474.0
160	161	0.035804	0.000072	Midtown Center	161	Manhattan	POLYGON ((991081.026 214453.698, 990952.644 21...	161.0	85401.0

The next step is creating a color map (choropleth map) showing zones by the number of trips taken.

Again, you can use the `zones.plot()` method for this. [Plot Method GPD]

But first, you need to define the figure and axis for the plot.

```
fig, ax = plt.subplots(1, 1, figsize = (12, 10))
```

This function creates a figure (fig) and a single subplot (ax)

After setting up the figure and axis, we can proceed to plot the GeoDataFrame on this axis. This is done in the next step where we use the plot method of the GeoDataFrame.

You can define the following parameters in the `zones.plot()` method:

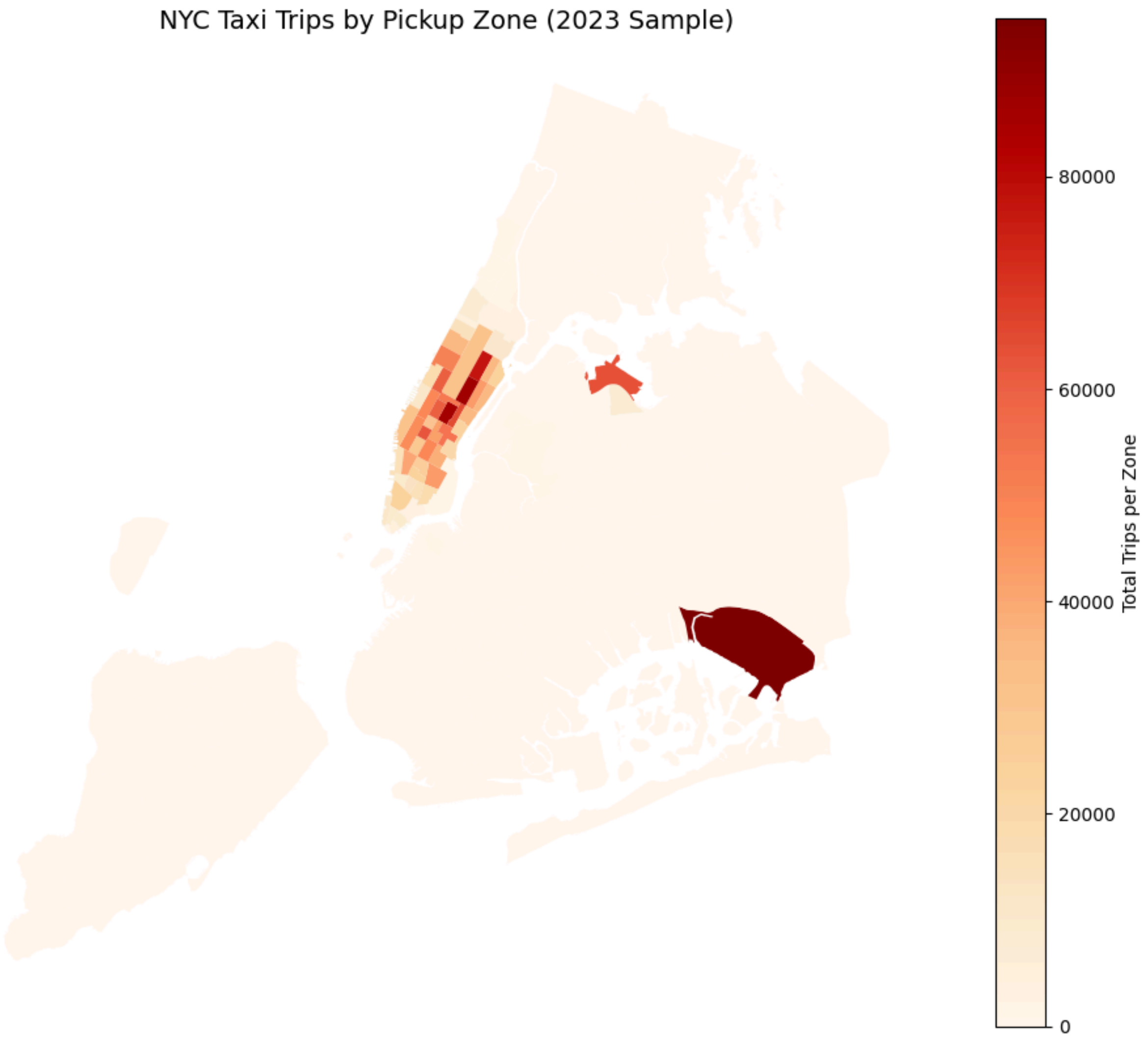
```
column = '',
ax = ax,
legend = True,
legend_kwds = {'label': "label", 'orientation': "<horizontal/vertical>"}
```

To display the plot, use `plt.show()`.

3.1.13 [3 marks]

Plot a color-coded map showing zone-wise trips

```
# Define figure and axis

import matplotlib.pyplot as plt

# Create figure and axis
fig, ax = plt.subplots(1, 1, figsize=(12, 10))

# Plot choropleth
zones.plot(column='trip_count',
           ax=ax,
           cmap='OrRd',
           legend=True,
           legend_kwds={'label': "Total Trips per Zone", 'orientation': "vertical"})

# Set title
plt.title("NYC Taxi Trips by Pickup Zone (2023 Sample)", fontsize=14)
plt.axis('off')
plt.show()

# Plot the map and display it
```




```
# can you try displaying the zones DF sorted by the number of trips?
```

Loaded NYC taxi zone shapefile using GeoPandas.

Merged trip data with zone polygons using PULocationID.

Grouped data to calculate total pickups per zone.

Mapped the data on a choropleth showing high-demand areas like Manhattan and JFK.

This visualization helps identify taxi hot-spots and underserved regions.

Here we have completed the temporal, financial and geographical analysis on the trip records.

Compile your findings from general analysis below:

You can consider the following points:

- Busiest hours, days and months
- Trends in revenue collected
- Trends in quarterly revenue
- How fare depends on trip distance, trip duration and passenger counts
- How tip amount depends on trip distance
- Busiest zones

3.2 Detailed EDA: Insights and Strategies

[50 marks]

Having performed basic analyses for finding trends and patterns, we will now move on to some detailed analysis focussed on operational efficiency, pricing strategies, and customer experience.

Operational Efficiency

Analyze variations by time of day and location to identify bottlenecks or inefficiencies in routes

3.2.1 [3 marks]
Identify slow routes by calculating the average time taken by cabs to get from one zone to another at different hours of the day.

Speed on a route *X* for hour *Y* = (*distance of the route X / average trip duration for hour Y*)

```
# Find routes which have the slowest speeds at different times of the day
# First, compute trip duration in minutes
df_financial['trip_duration'] = (
    pd.to_datetime(df_financial['tpep_dropoff_datetime']) -
    pd.to_datetime(df_financial['tpep_pickup_datetime'])
).dt.total_seconds() / 60

# Filter out durations <= 0 to avoid invalid cases
df_valid_speed = df_financial[df_financial['trip_duration'] > 0]

# Group by pickup + dropoff + hour
avg_speed_df = df_valid_speed.groupby(['PULocationID', 'DOLocationID', 'pickup_hour']).agg({
    'trip_distance': 'mean',
    'trip_duration': 'mean'
}).reset_index()

# Calculate speed in miles per minute (or multiply by 60 for mph)
avg_speed_df['speed_mph'] = (avg_speed_df['trip_distance'] / avg_speed_df['trip_duration']) * 60

# Find slowest routes
slowest_routes = avg_speed_df.sort_values('speed_mph').head(10)
slowest_routes
```

```
<ipython-input-39-e172cc99b809>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['trip_duration'] = (
```

	PULocationID	DOLocationID	pickup_hour	trip_distance	trip_duration	speed_mph
102265	232	65	13	0.490000	5522.433333	0.005324
114897	243	264	17	0.180000	1389.550000	0.007772
61239	142	142	5	0.560000	1413.550000	0.023770
120397	258	258	1	0.020000	45.750000	0.026230
33386	100	7	8	0.220000	334.433333	0.039470
6448	40	65	21	1.120000	1434.433333	0.046848
39482	113	235	22	0.280000	349.233333	0.048105
89204	194	194	16	0.010000	12.266667	0.048913
95233	226	145	18	1.563333	1810.761111	0.051801
9702	45	45	10	0.050000	50.433333	0.059484

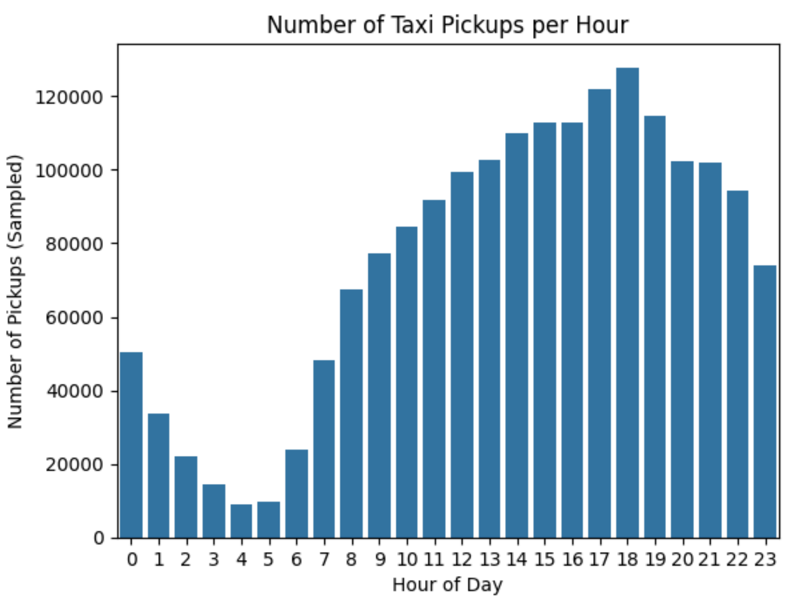
Next steps: Generate code with slowest_routes | View recommended plots | New interactive sheet

How does identifying high-traffic, high-demand routes help us?

3.2.2 [3 marks]

Calculate the number of trips at each hour of the day and visualise them. Find the busiest hour and show the number of trips for that hour.

```
# Visualise the number of trips per hour and find the busiest hour

import seaborn as sns
import matplotlib.pyplot as plt

# Group by pickup_hour
hourly_trips = df_financial['pickup_hour'].value_counts().sort_index()

# Visualize
sns.barplot(x=hourly_trips.index, y=hourly_trips.values)
plt.title("Number of Taxi Pickups per Hour")
plt.xlabel("Hour of Day")
plt.ylabel("Number of Pickups (Sampled)")
plt.show()

# Busiest hour
busiest_hour = hourly_trips.idxmax()
busiest_hour_count = hourly_trips.max()
print(f"Busiest Hour: {busiest_hour} | Trips: {busiest_hour_count}")
```




```
Busiest Hour: 18 | Trips: 127864
```

Remember, we took a fraction of trips. To find the actual number, you have to scale the number up by the sampling ratio.

3.2.3 [2 mark]

Find the actual number of trips in the five busiest hours

```
# Scale up the number of trips

# Fill in the value of your sampling fraction and use that to scale up the numbers
#sample_fraction =

sample_fraction = 0.05  # You used 5% sampling

# Top 5 busiest hours
top5_hours = hourly_trips.sort_values(ascending=False).head(5)
top5_scaled = (top5_hours / sample_fraction).astype(int)

print("Estimated Actual Trips for Top 5 Hours:")
print(top5_scaled)
```

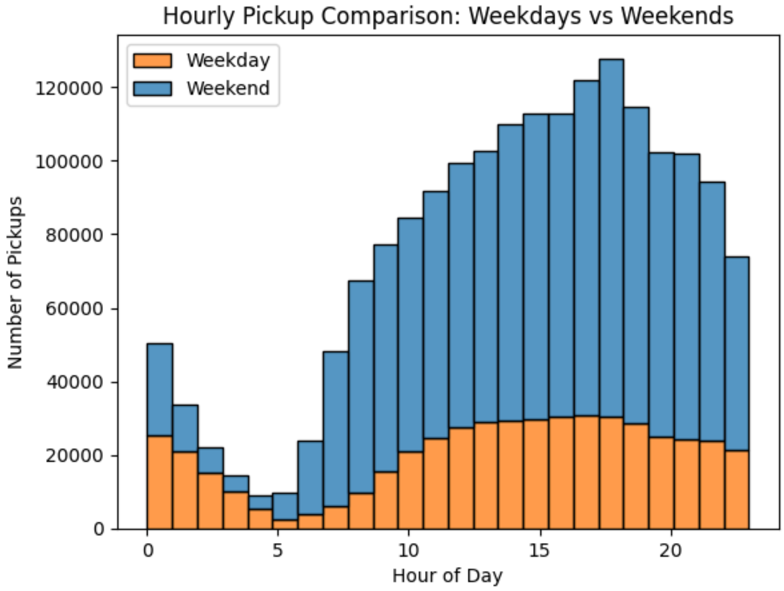
```
Estimated Actual Trips for Top 5 Hours:
pickup_hour
18    2557280
17    2441380
19    2296260
15    2256680
16    2254660
Name: count, dtype: int64
```

3.2.4 [3 marks]

Compare hourly traffic pattern on weekdays. Also compare for weekend.

```
# Compare traffic trends for the week days and weekends

# Extract weekday
df_financial['pickup_day'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.day_name()
df_financial['is_weekend'] = df_financial['pickup_day'].isin(['Saturday', 'Sunday'])

# Plot hourly patterns
sns.histplot(data=df_financial, x='pickup_hour', hue='is_weekend', multiple='stack', bins=24)
plt.title("Hourly Pickup Comparison: Weekdays vs Weekends")
plt.xlabel("Hour of Day")
plt.ylabel("Number of Pickups")
plt.legend(["Weekday", "Weekend"])
plt.show()
```

```
<ipython-input-42-4b242c70b7d9>:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['pickup_day'] = pd.to_datetime(df_financial['tpep_pickup_datetime']).dt.day_name()
<ipython-input-42-4b242c70b7d9>:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['is_weekend'] = df_financial['pickup_day'].isin(['Saturday', 'Sunday'])
```

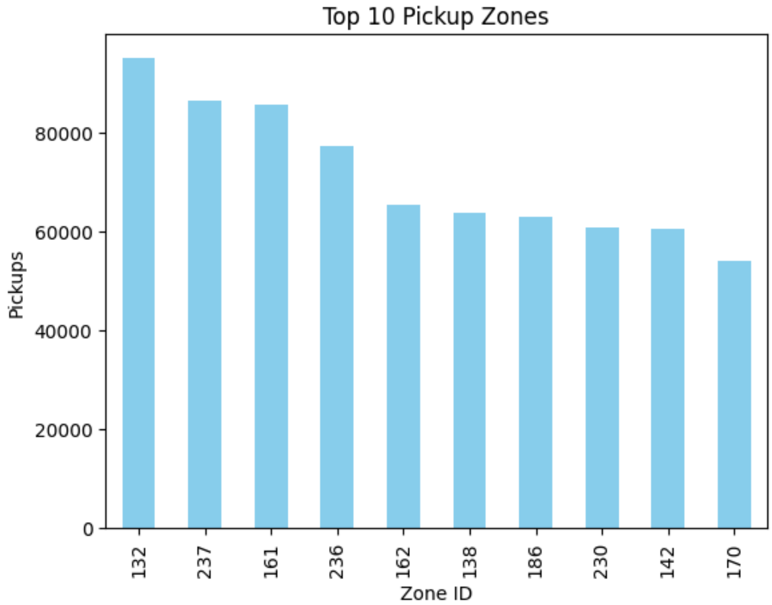


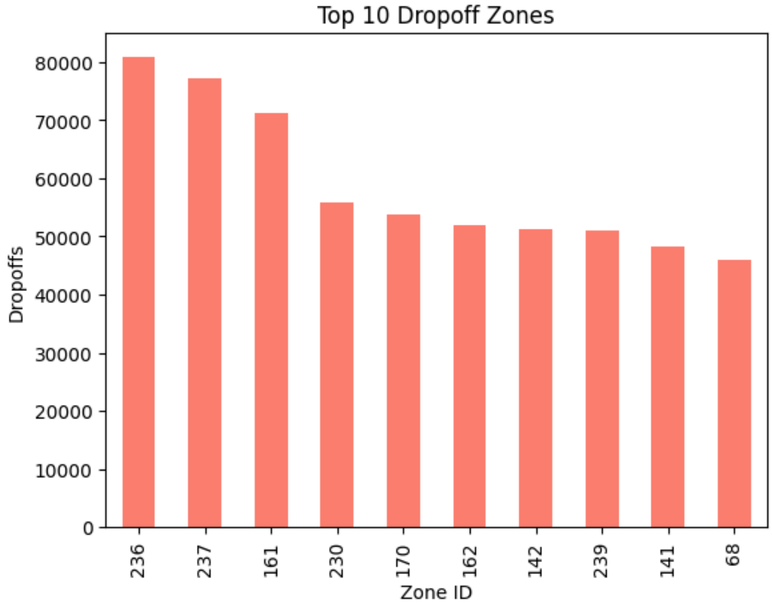
What can you infer from the above patterns? How will finding busy and quiet hours for each day help us?

3.2.5 [3 marks]

Identify top 10 zones with high hourly pickups. Do the same for hourly dropoffs. Show pickup and dropoff trends in these zones.

```
# Find top 10 pickup and dropoff zones

top_pu_zones = df_financial['PULocationID'].value_counts().head(10)
top_do_zones = df_financial['DOLocationID'].value_counts().head(10)

# Visualize
top_pu_zones.plot(kind='bar', color='skyblue', title='Top 10 Pickup Zones')
plt.xlabel('Zone ID')
plt.ylabel('Pickups')
plt.show()

top_do_zones.plot(kind='bar', color='salmon', title='Top 10 Dropoff Zones')
plt.xlabel('Zone ID')
plt.ylabel('Dropoffs')
plt.show()
```





3.2.6 [3 marks]

Find the ratio of pickups and dropoffs in each zone. Display the 10 highest (pickup/drop) and 10 lowest (pickup/drop) ratios.

```
# Find the top 10 and bottom 10 pickup/dropoff ratios

pickup_counts = df_financial['PULocationID'].value_counts()
dropoff_counts = df_financial['DOLocationID'].value_counts()

# Create a ratio DataFrame
ratios_df = pd.DataFrame({
    'pickup': pickup_counts,
    'dropoff': dropoff_counts
}).fillna(0)

ratios_df['pickup_drop_ratio'] = ratios_df['pickup'] / (ratios_df['dropoff'] + 1)

# Top & Bottom 10
top_ratios = ratios_df.sort_values('pickup_drop_ratio', ascending=False).head(10)
bottom_ratios = ratios_df.sort_values('pickup_drop_ratio', ascending=True).head(10)

print("Top 10 Pickup/Dropoff Ratios:\n", top_ratios)
print("\nBottom 10 Pickup/Dropoff Ratios:\n", bottom_ratios)
```

```
Top 10 Pickup/Dropoff Ratios:
       pickup  dropoff  pickup_drop_ratio
70    8194.0    868.0           9.429229
132  94946.0  19329.0           4.911847
138  63682.0  21786.0           2.922936
199      2.0      0.0           2.000000
```

```
186  62991.0  39758.0           1.584321
114  23980.0  17427.0           1.375947
43   30603.0  22241.0           1.375910
249  40207.0  30270.0           1.328235
162  65211.0  51854.0           1.257564
161  85401.0  71152.0           1.200245

Bottom 10 Pickup/Dropoff Ratios:
      pickup  dropoff  pickup_drop_ratio
30       0.0     18.0           0.000000
245      0.0     30.0           0.000000
221      0.0     33.0           0.000000
176      0.0     12.0           0.000000
99       0.0      3.0           0.000000
109      0.0     25.0           0.000000
1       47.0   5159.0           0.009109
27       1.0     38.0           0.025641
257     21.0    749.0           0.028000
251      1.0     31.0           0.031250
```

3.2.7 [3 marks]

Identify zones with high pickup and dropoff traffic during night hours (11PM to 5AM)

```
# During night hours (11pm to 5am) find the top 10 pickup and dropoff zones
# Note that the top zones should be of night hours and not the overall top zones

night_df = df_financial[(df_financial['pickup_hour'] >= 23) | (df_financial['pickup_hour'] <= 5)]

night_pu = night_df['PULocationID'].value_counts().head(10)
night_do = night_df['DOLocationID'].value_counts().head(10)

print("Top 10 Nighttime Pickup Zones:\n", night_pu)
print("\nTop 10 Nighttime Dropoff Zones:\n", night_do)
```

```
Top 10 Nighttime Pickup Zones:
 PULocationID
79     15432
132    14328
249    12393
48     10362
148     9561
114     8699
230     8116
186     6893
164     6080
68      5957
Name: count, dtype: int64

Top 10 Nighttime Dropoff Zones:
 DOLocationID
79     8225
48     6793
170    6196
68     5764
107    5693
141    5227
263    4936
249    4883
230    4560
229    4338
Name: count, dtype: int64
```

Now, let us find the revenue share for the night time hours and the day time hours. After this, we will move to deciding a pricing strategy.

3.2.8 [2 marks]

Find the revenue share for nighttime and daytime hours.

```
# Filter for night hours (11 PM to 5 AM)

night_revenue = night_df['total_amount'].sum()
day_revenue = df_financial[~((df_financial['pickup_hour'] >= 23) | (df_financial['pickup_hour'] <= 5))]['total_amount'].sum()

total = night_revenue + day_revenue
print(f"Night Revenue Share: {night_revenue / total:.2%}")
print(f"Day Revenue Share: {day_revenue / total:.2%}")
```

```
Night Revenue Share: 11.97%
Day Revenue Share: 88.03%
```

Pricing Strategy

3.2.9 [2 marks]

For the different passenger counts, find the average fare per mile per passenger.

For instance, suppose the average fare per mile for trips with 3 passengers is 3 USD/mile, then the fare per mile per passenger will be 1 USD/mile.

```
# Analyse the fare per mile per passenger for different passenger counts

# Filter valid trips
valid_fare = df_financial[(df_financial['trip_distance'] > 0) & (df_financial['passenger_count'] > 0)]

# Compute fare per mile per passenger
valid_fare['fare_per_mile_per_passenger'] = valid_fare['fare_amount'] / valid_fare['trip_distance'] / valid_fare['passenger_count']

# Group by passenger count
ppc_analysis = valid_fare.groupby('passenger_count')['fare_per_mile_per_passenger'].mean()
print("Fare per mile per passenger:\n", ppc_analysis)
```

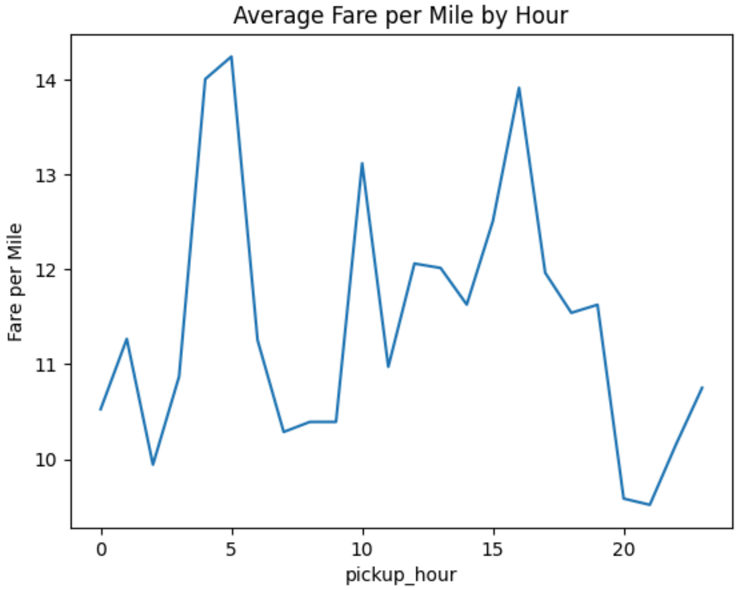
```
Fare per mile per passenger:
 passenger_count
1.0    11.058845
2.0     6.432401
3.0     3.908099
4.0     4.363227
5.0     1.709614
6.0     1.350744
7.0     1.308835
8.0    28.627266
9.0    76.098002
Name: fare_per_mile_per_passenger, dtype: float64
<ipython-input-47-cd3e3592efaf>:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  valid_fare['fare_per_mile_per_passenger'] = valid_fare['fare_amount'] / valid_fare['trip_distance'] / valid_fare['passenger_count
```

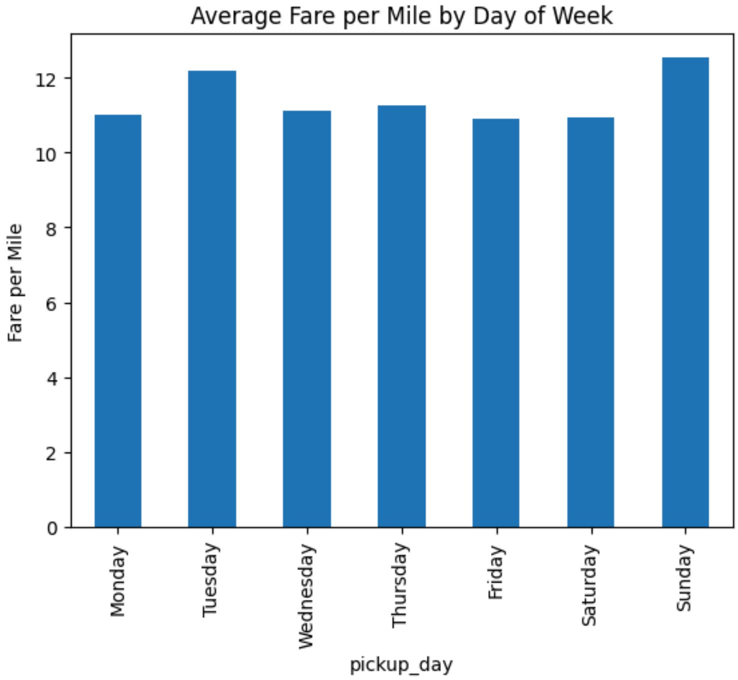
3.2.10 [3 marks]

Find the average fare per mile by hours of the day and by days of the week

```
# Compare the average fare per mile for different days and for different times of the day

# Fare per mile
df_financial['fare_per_mile'] = df_financial['fare_amount'] / df_financial['trip_distance']

# By hour
hourly_fare = df_financial.groupby('pickup_hour')['fare_per_mile'].mean()
hourly_fare.plot(title='Average Fare per Mile by Hour', ylabel='Fare per Mile')
plt.show()

# By weekday
weekday_fare = df_financial.groupby('pickup_day')['fare_per_mile'].mean().reindex(
    ['Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday']
)
weekday_fare.plot(kind='bar', title='Average Fare per Mile by Day of Week', ylabel='Fare per Mile')
plt.show()
```

```
<ipython-input-48-a58f1a1027a4>:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versu
  df_financial['fare_per_mile'] = df_financial['fare_amount'] / df_financial['trip_distance']
```

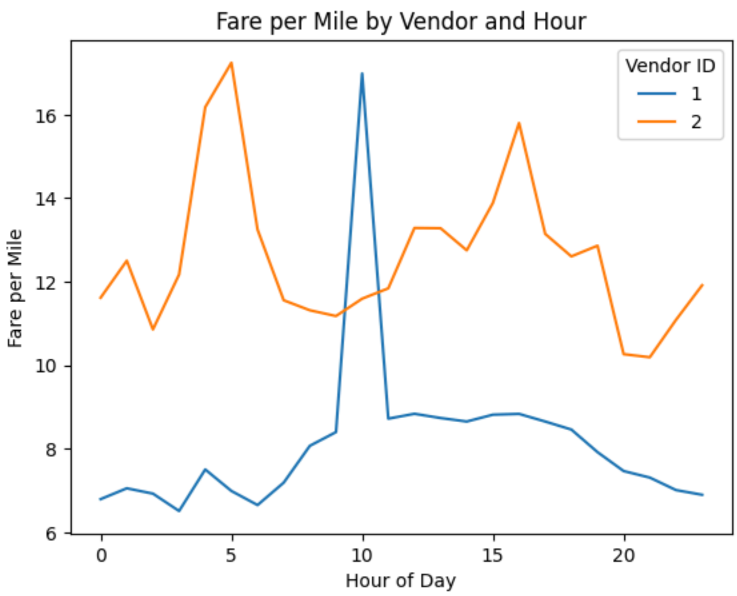




3.2.11 [3 marks]

Analyse the average fare per mile for the different vendors for different hours of the day

```
# Compare fare per mile for different vendors

vendor_hour_fare = df_financial.groupby(['VendorID', 'pickup_hour'])['fare_per_mile'].mean().unstack(0)

# Plot for each vendor
vendor_hour_fare.plot(title='Fare per Mile by Vendor and Hour')
plt.ylabel('Fare per Mile')
plt.xlabel('Hour of Day')
plt.legend(title='Vendor ID')
plt.show()
```



3.2.12 [5 marks]

Compare the fare rates of the different vendors in a tiered fashion. Analyse the average fare per mile for distances upto 2 miles. Analyse the fare per mile for distances from 2 to 5 miles. And then for distances more than 5 miles.

```
# Defining distance tiers

def fare_tier(row):
    if row['trip_distance'] <= 2:
        return '0-2 miles'
    elif row['trip_distance'] <= 5:
        return '2-5 miles'
    else:
        return '5+ miles'

df_financial['distance_tier'] = df_financial.apply(fare_tier, axis=1)

# Average fare per mile by vendor and distance tier
tiered_fare = df_financial.groupby(['VendorID', 'distance_tier'])['fare_per_mile'].mean().unstack()

print("Tiered fare per mile by vendor:\n", tiered_fare)
```

```
<ipython-input-50-1663e9b1d13d>:11: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  df_financial['distance_tier'] = df_financial.apply(fare_tier, axis=1)
Tiered fare per mile by vendor:
 distance_tier  0-2 miles  2-5 miles  5+ miles
VendorID
1             10.673070   6.381262  4.425249
2             17.933669   6.549258  4.503295
```

Customer Experience and Other Factors

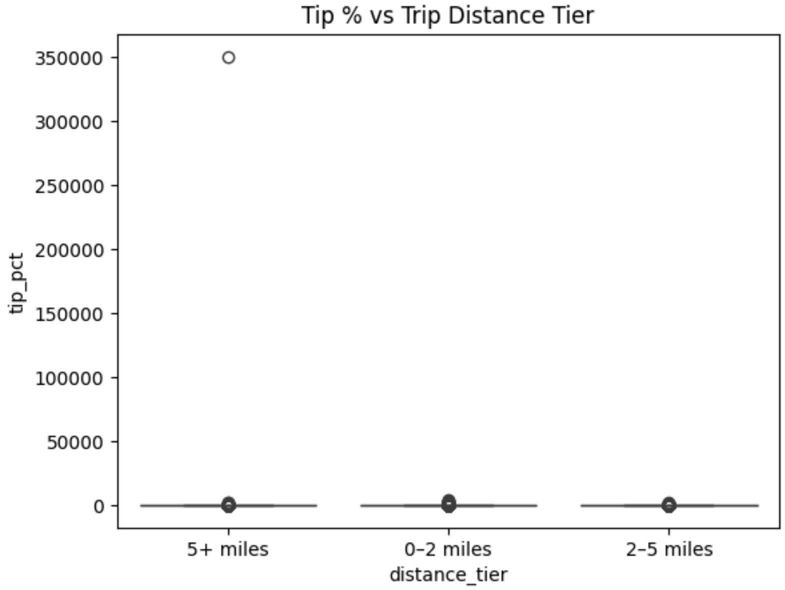
3.2.13 [5 marks]

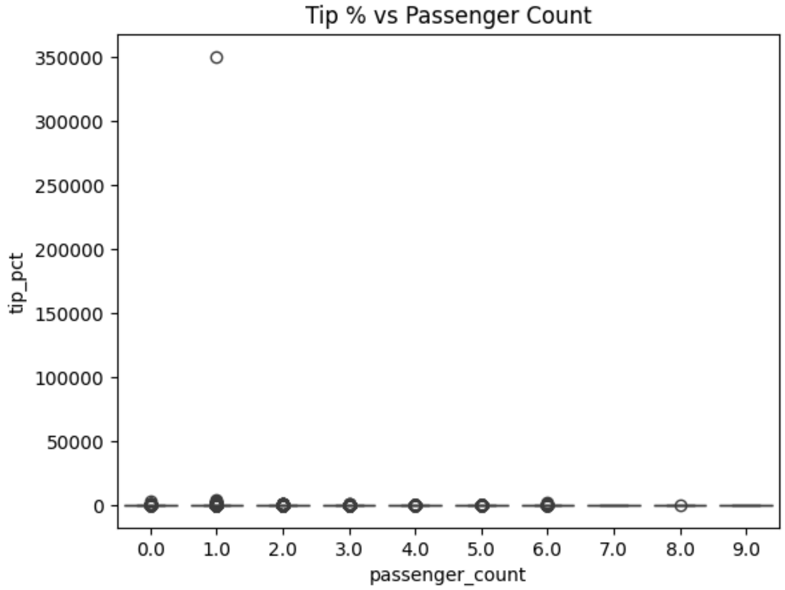
Analyse average tip percentages based on trip distances, passenger counts and time of pickup. What factors lead to low tip percentages?

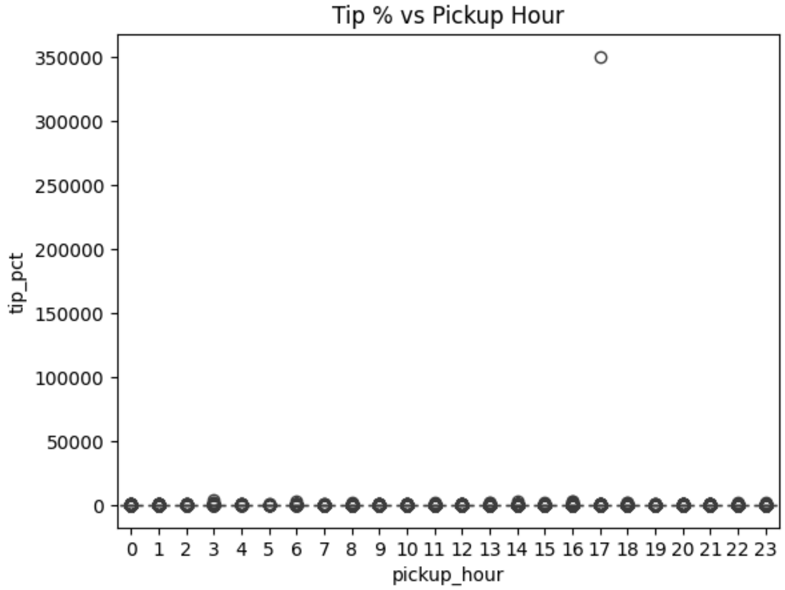
```
#  Analyze tip percentages based on distances, passenger counts and pickup times
# Tip percentage
df_financial['tip_pct'] = (df_financial['tip_amount'] / df_financial['fare_amount']) * 100

# Tip vs Distance
sns.boxplot(x='distance_tier', y='tip_pct', data=df_financial)
plt.title("Tip % vs Trip Distance Tier")
plt.show()

# Tip vs Passenger Count
sns.boxplot(x='passenger_count', y='tip_pct', data=df_financial)
plt.title("Tip % vs Passenger Count")
plt.show()
```

```
# Tip vs Pickup Hour
sns.boxplot(x='pickup_hour', y='tip_pct', data=df_financial)
plt.title("Tip % vs Pickup Hour")
plt.show()
```

```
<ipython-input-55-741c1de5b5c0>:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versu
  df_financial['tip_pct'] = (df_financial['tip_amount'] / df_financial['fare_amount']) * 100
```







Additional analysis [optional]: Let's try comparing cases of low tips with cases of high tips to find out if we find a clear aspect that drives up the tipping behaviours

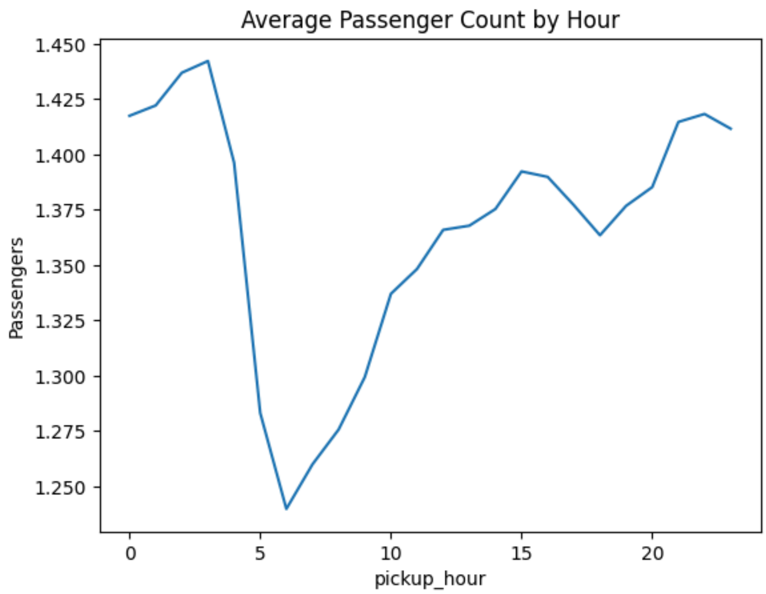
```
# Compare trips with tip percentage < 10% to trips with tip percentage > 25%

low_tip = df_financial[df_financial['tip_pct'] < 10]
high_tip = df_financial[df_financial['tip_pct'] > 25]

print("Low tipper average fare:", low_tip['fare_amount'].mean())
print("High tipper average fare:", high_tip['fare_amount'].mean())
```

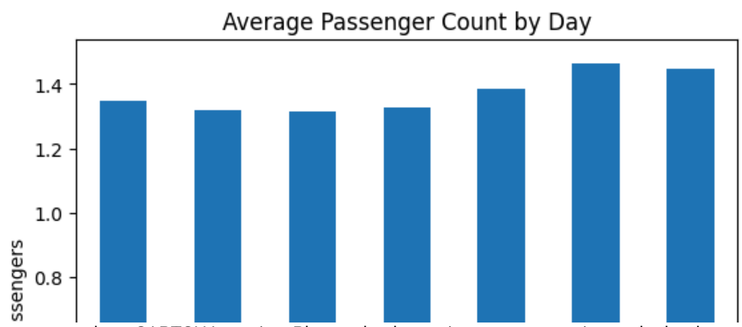
```
Low tipper average fare: 21.885989080387795
High tipper average fare: 14.414397165474755
```

3.2.14 [3 marks]

Analyse the variation of passenger count across hours and days of the week.

```
# See how passenger count varies across hours and days


# Avg passenger count by hour
hourly_passenger = df_financial.groupby('pickup_hour')['passenger_count'].mean()
hourly_passenger.plot(title="Average Passenger Count by Hour", ylabel="Passengers")
plt.show()

# By day of week
day_passenger = df_financial.groupby('pickup_day')['passenger_count'].mean().reindex(
    ['Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday', 'Sunday']
)
day_passenger.plot(kind='bar', title="Average Passenger Count by Day", ylabel="Passengers")
plt.show()
```





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