```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

data cleaning

```
df_makers= pd.read_csv('electric_vehicle_sales_by_makers.csv')
df_date=pd.read_csv('dim_date.csv')
df_sales=pd.read_csv('electric_vehicle_sales_by_state.csv')

df_makers.head(), df_date.head(), df_sales.head()
```

```
(        date vehicle_category         maker  electric_vehicles_sold
 0  01-Apr-21       2-Wheelers  OLA ELECTRIC                       0
 1  01-Apr-22       2-Wheelers      OKAYA EV                       0
 2  01-May-21       2-Wheelers  OLA ELECTRIC                       0
 3  01-Jun-21       2-Wheelers  OLA ELECTRIC                       0
 4  01-Jul-21       2-Wheelers  OLA ELECTRIC                       0,
         date  fiscal_year quarter
 0  01-Apr-21         2022      Q1
 1  01-May-21         2022      Q1
 2  01-Jun-21         2022      Q1
 3  01-Jul-21         2022      Q2
 4  01-Aug-21         2022      Q2,
         date   state vehicle_category  electric_vehicles_sold  \
 0  01-Apr-21  Sikkim       2-Wheelers                       0
 1  01-Apr-21  Sikkim       4-Wheelers                       0
 2  01-May-21  Sikkim       2-Wheelers                       0
 3  01-May-21  Sikkim       4-Wheelers                       0
 4  01-Jun-21  Sikkim       2-Wheelers                       0

    total_vehicles_sold
 0                  398
 1                  361
 2                  113
 3                   98
 4                  229  )
```

```
df_makers.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 816 entries, 0 to 815
Data columns (total 4 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   date                   816 non-null    object
 1   vehicle_category       816 non-null    object
 2   maker                  816 non-null    object
 3   electric_vehicles_sold  816 non-null    int64
```

```
dtypes: int64(1), object(3)
memory usage: 25.6+ KB
```

```
#checks datatypes for date
```

```
df_date.dtypes
```

```
date           object
fiscal_year     int64
quarter        object
dtype: object
```

```
#date was having object datatypes we have to convert it into datetime datatypes
```

```
df_date["date"]=pd.to_datetime(df_date["date"],format='%d-%b-%y')
```

```
df_date.dtypes
```

```
date           datetime64[ns]
fiscal_year             int64
quarter                object
dtype: object
```

```
#checks datatypes for df_makers
```

```
df_makers.dtypes
```

```
date                      object
vehicle_category          object
maker                     object
electric_vehicles_sold     int64
dtype: object
```

```
#change date type for df_makers
df_makers["date"]=pd.to_datetime(df_makers["date"],format='%d-%b-%y')
```

```
df_makers.dtypes
```

```
date                      datetime64[ns]
vehicle_category                  object
maker                             object
electric_vehicles_sold             int64
dtype: object
```

```
#chheck date type for df_sales
df_sales.dtypes
```

```
date                      object
state                     object
vehicle_category          object
electric_vehicles_sold     int64
```

```
total_vehicles_sold        int64
dtype: object
```

```
#change date type for df_sales
df_sales["date"]=pd.to_datetime(df_sales["date"],format='%d-%b-%y')

df_sales.dtypes
```

```
date                       datetime64[ns]
state                              object
vehicle_category                   object
electric_vehicles_sold              int64
total_vehicles_sold                 int64
dtype: object
```

```
df_sales.shape
```

```
(2445, 5)
```

```
df_sales.head()
```

```
        date   state vehicle_category  electric_vehicles_sold  \
0 2021-04-01  Sikkim       2-Wheelers                       0
1 2021-04-01  Sikkim       4-Wheelers                       0
2 2021-05-01  Sikkim       2-Wheelers                       0
3 2021-05-01  Sikkim       4-Wheelers                       0
4 2021-06-01  Sikkim       2-Wheelers                       0

   total_vehicles_sold
0                  398
1                  361
2                  113
3                   98
4                  229
```

```
df_sales['state'].unique()
```

```
array(['Sikkim', 'Andaman & Nicobar Island', 'Arunachal Pradesh',
'Assam',
       'Chhattisgarh', 'DNH and DD', 'Jammu and Kashmir', 'Ladakh',
       'Manipur', 'Meghalaya', 'Mizoram', 'Nagaland', 'Puducherry',
       'Tripura', 'Bihar', 'Chandigarh', 'Delhi', 'Madhya Pradesh',
       'Odisha', 'Punjab', 'Uttarakhand', 'Himachal Pradesh',
       'Andaman & Nicobar', 'Haryana', 'Jharkhand', 'Andhra Pradesh',
       'Goa', 'Gujarat', 'Karnataka', 'Kerala', 'Maharashtra',
       'Rajasthan', 'Tamil Nadu', 'Uttar Pradesh', 'West Bengal'],
      dtype=object)
```

```
#Replace Andaman&Nicobar with andaman&nicobar island
df_state = df_sales['state'].replace('Andaman & Nicobar', 'Andaman &
Nicobar Island')
```

```
len(df_state.unique())
```

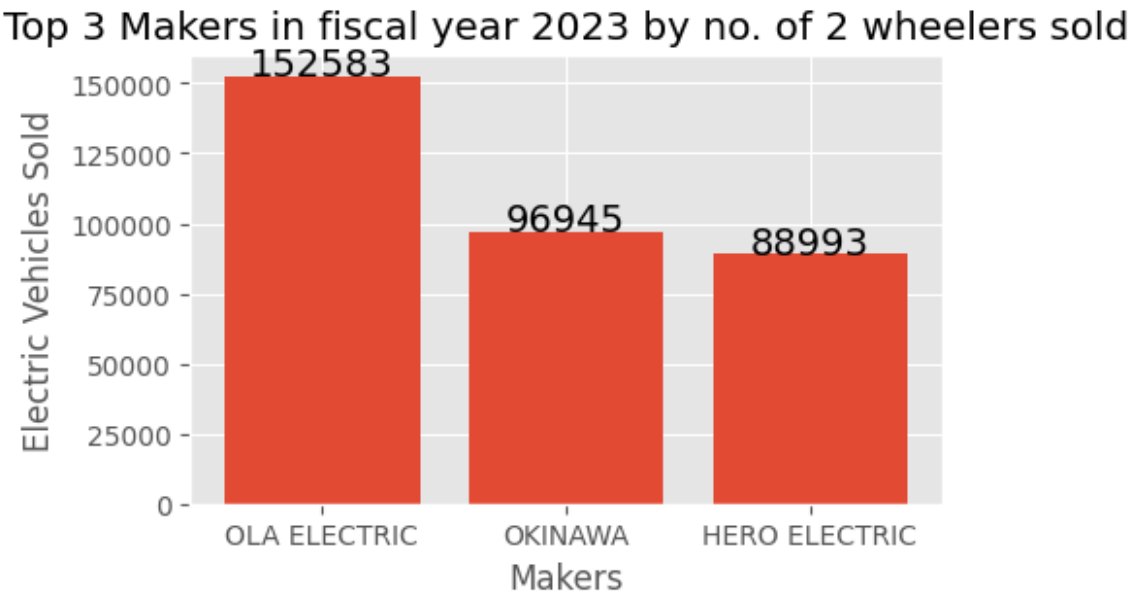
```
34
```

Question 1: List the top 3 and bottom 3 makers for the fiscal years 2023 and 2024 in terms of the number of 2-wheelers sold.

```
plt.style.use('ggplot')

#Top 3 makers in fiscal year 2023 by number of 2 wheelers sold

df=pd.merge(left=df_date,right=df_makers,on="date",how="inner")
df=df[(df["fiscal_year"]==2023)&(df["vehicle_category"]=="2-
Wheelers")]
df=df.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().sort_values(by="electric_vehicles_sol
d",ascending=False).head(3)
df
```

```
           maker  electric_vehicles_sold
8   OLA ELECTRIC                  152583
7        OKINAWA                   96945
4  HERO ELECTRIC                   88993
```

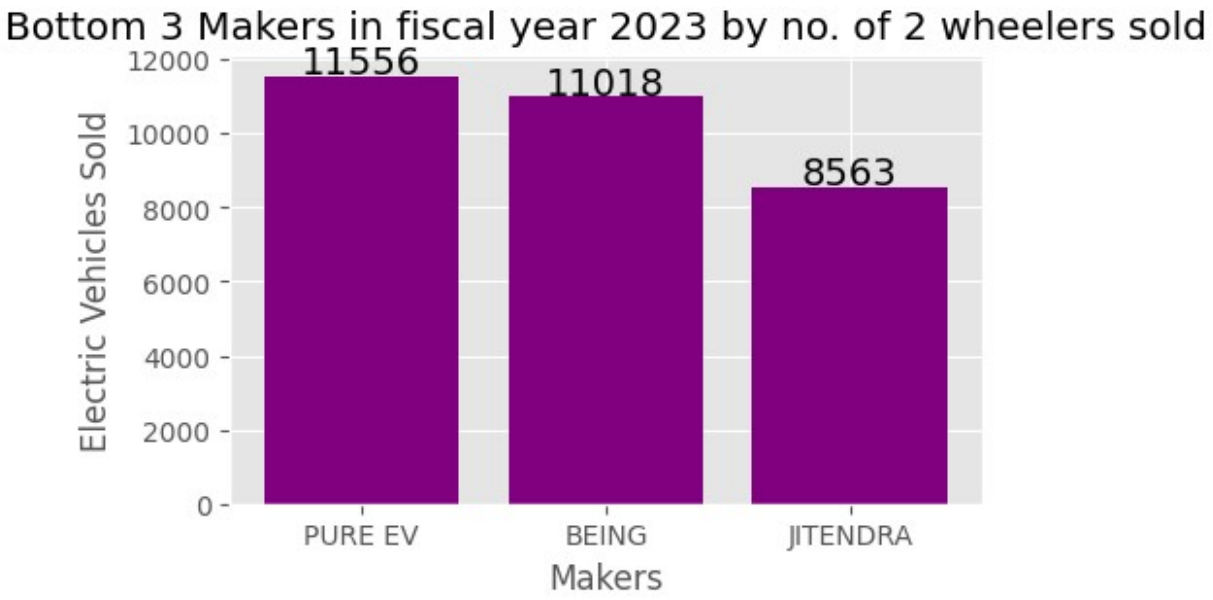
```
#plot graph

plt.style.use('ggplot')
plt.figure(figsize=(5,3))
plt.bar(df["maker"],df["electric_vehicles_sold"],align="center")
for i,value in enumerate(df["electric_vehicles_sold"]):
  plt.text(i,value +50 , str(value),ha='center',fontsize=14)
plt.title("Top 3 Makers in fiscal year 2023 by no. of 2 wheelers
sold")
plt.xlabel("Makers")
plt.ylabel("Electric Vehicles Sold")
plt.show()
```




```
#bottom 3 makers in fiscal year 2023 by number of 2 wheelers sold
df=pd.merge(left=df_date,right=df_makers,on="date",how="inner")
df=df[(df["fiscal_year"]==2023)&(df["vehicle_category"]=="2-
Wheelers")]
df=df.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().sort_values(by="electric_vehicles_sol
d",ascending=False).tail(3)
df
```

	maker	electric_vehicles_sold
10	PURE EV	11556
3	BEING	11018
5	JITENDRA	8563

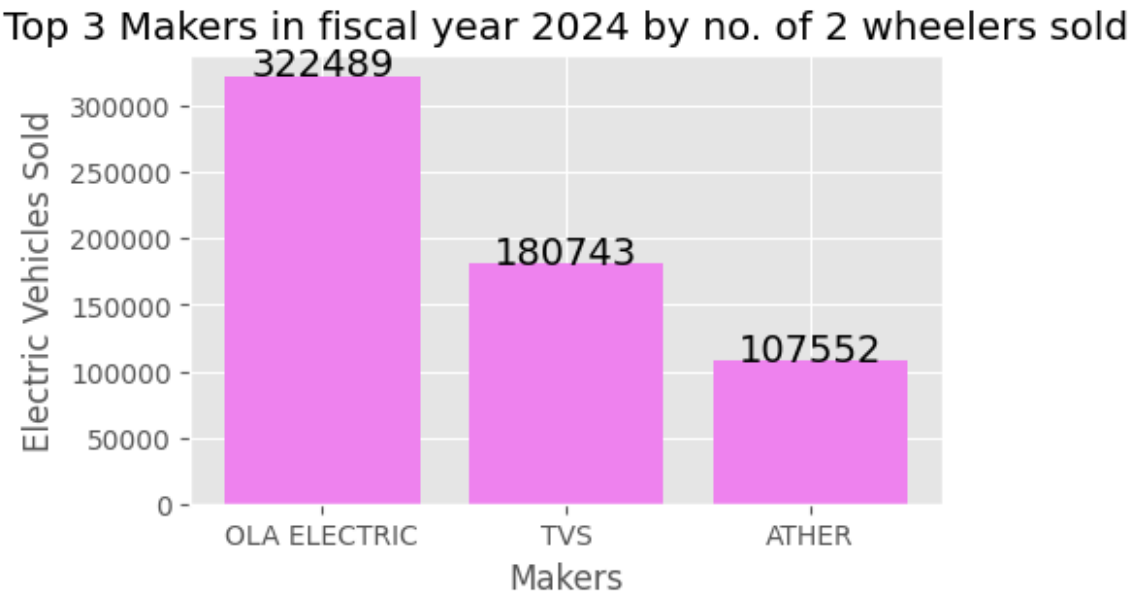
```
#plot graph for top 3 makers in fiscal year 2023 by number of 2
wheelers sold
plt.figure(figsize=(5, 3))
plt.bar(df["maker"], df["electric_vehicles_sold"], align="center",
color='purple')
for i, value in enumerate(df["electric_vehicles_sold"]):
    plt.text(i, value + 50, str(value), ha='center', fontsize=14)
plt.title("Bottom 3 Makers in fiscal year 2023 by no. of 2 wheelers
sold")
plt.xlabel("Makers")
plt.ylabel("Electric Vehicles Sold")
plt.show()
```




```
#top 3 makers in fiscal year 2024 by number of 2 wheelers sold
df=pd.merge(left=df_date,right=df_makers,on="date",how="inner")
df=df[(df["fiscal_year"]==2024)&(df["vehicle_category"]=="2-
Wheelers")]
df=df.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().sort_values(by="electric_vehicles_sol
d",ascending=False).head(3)
df
```

	maker	electric_vehicles_sold
9	OLA ELECTRIC	322489
12	TVS	180743
1	ATHER	107552

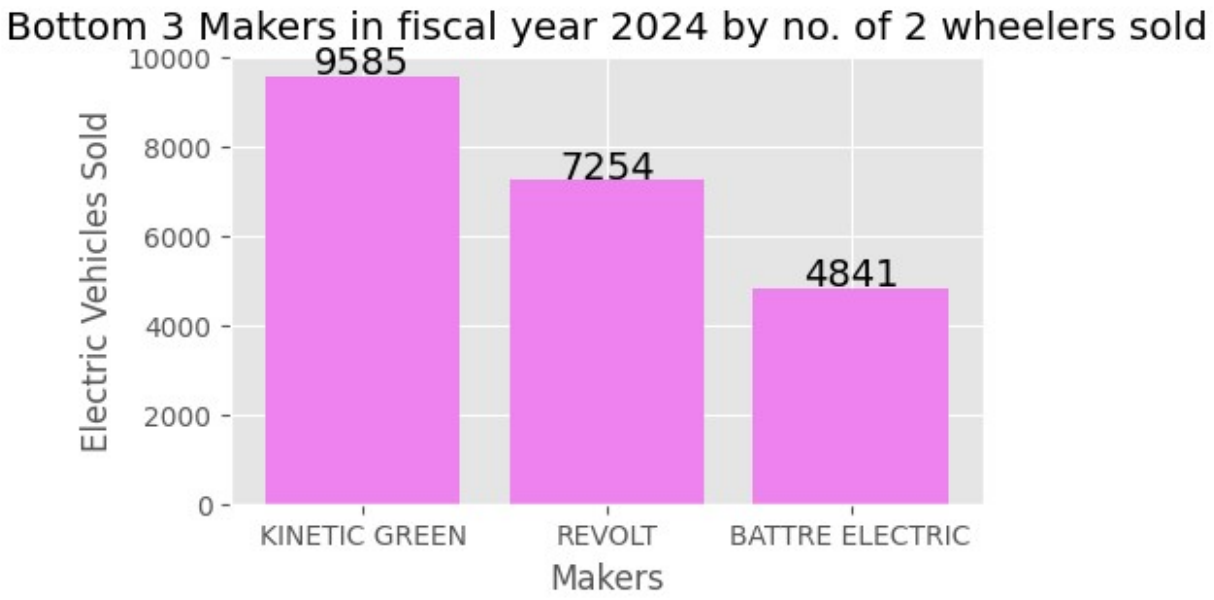
```
#plot graph for top 3 makers in fiscal year 2023 by number of 2
wheelers sold
plt.figure(figsize=(5,3))
plt.bar(df["maker"], df["electric_vehicles_sold"], align="center",
color="violet")
for i, value in enumerate(df["electric_vehicles_sold"]):
    plt.text(i, value + 50, str(value), ha='center', fontsize=14)
plt.title("Top 3 Makers in fiscal year 2024 by no. of 2 wheelers
sold")
plt.xlabel("Makers")
plt.ylabel("Electric Vehicles Sold")
plt.show()
```




```
#bottom 3 makers in fiscal year 2024 by number of 2 wheelers sold
df=pd.merge(left=df_date,right=df_makers,on="date",how="inner")
df=df[(df["fiscal_year"]==2024)&(df["vehicle_category"]=="2-
Wheelers")]
df=df.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().sort_values(by="electric_vehicles_sol
d",ascending=False).tail(3)
df
```

	maker	electric_vehicles_sold
6	KINETIC GREEN	9585
11	REVOLT	7254
3	BATTRE ELECTRIC	4841

```
#plot graph for bottom 3 makers in fiscal year 2024 by number of 2
wheelers sold
plt.figure(figsize=(5,3))
plt.bar(df["maker"], df["electric_vehicles_sold"], align="center",
color='violet')
for i, value in enumerate(df["electric_vehicles_sold"]):
    plt.text(i, value + 50, str(value), ha='center', fontsize=14)
plt.title("Bottom 3 Makers in fiscal year 2024 by no. of 2 wheelers
sold")
plt.xlabel("Makers")
plt.ylabel("Electric Vehicles Sold")
plt.show()
```



Question 2: Identify the top 5 states with the highest penetration rate in 2-wheeler and 4-wheeler EV sales in FY 2024.

```
#Highest penetration rate in 2-wheeler and 4-wheeler EV sales in FY
2024

df_sales.head()
```

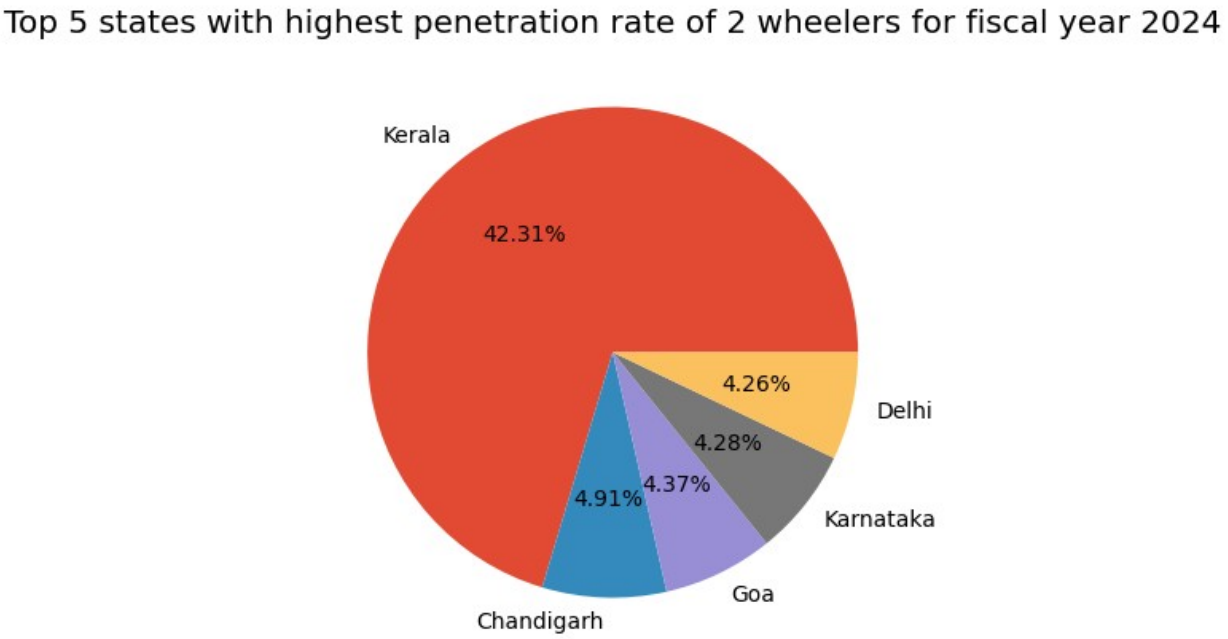
```
        date   state vehicle_category  electric_vehicles_sold  \
0 2021-04-01  Sikkim       2-Wheelers                       0
1 2021-04-01  Sikkim       4-Wheelers                       0
2 2021-05-01  Sikkim       2-Wheelers                       0
3 2021-05-01  Sikkim       4-Wheelers                       0
4 2021-06-01  Sikkim       2-Wheelers                       0

   total_vehicles_sold
0                  398
1                  361
2                  113
3                   98
4                  229
```

```
#top 5 states by penetration rate of 2-wheelers in FY 2024
df=pd.merge(left=df_date,right=df_sales,on="date",how="inner")
df=df[(df["fiscal_year"]==2024)&(df["vehicle_category"].isin(["2-
Wheelers", ]))]
df["penetration_rate"]=(df["electric_vehicles_sold"]/df["total_vehicle
s_sold"])*100
df=df.groupby(["state","vehicle_category"],as_index=False)
["penetration_rate"].mean().sort_values(by="penetration_rate",ascendin
g=False).head(5)
```

```
df
#display(["fiscal_year"])
```

	state	vehicle_category	penetration_rate
10	Goa	2-Wheelers	18.184784
17	Kerala	2-Wheelers	13.610393
16	Karnataka	2-Wheelers	11.510878
20	Maharashtra	2-Wheelers	10.157240
9	Delhi	2-Wheelers	9.700033

```
#plot the graph

total=df["penetration_rate"].sum()
plt.figure(figsize=(10,5))
plt.pie(df["penetration_rate"],labels=df["state"],autopct=lambda
x:"{:.2f}%".format(x*total/100),startangle=0)
plt.title("Top 5 states with highest penetration rate of 2 wheelers
for fiscal year 2024")
plt.show()
```

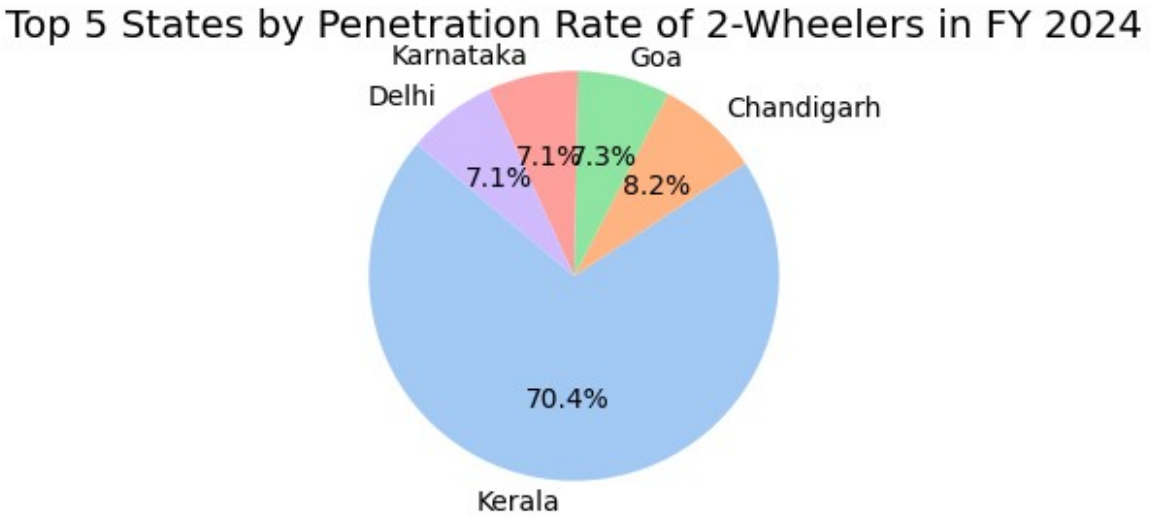



```
#top 5 states by penetration rate of 2-wheelers in FY 2024
df=pd.merge(left=df_date,right=df_sales,on="date",how="inner")
df=df[(df["fiscal_year"]==2024)&(df["vehicle_category"]=="4-
Wheelers")]
df["penetration_rate"]=(df["electric_vehicles_sold"]/df["total_vehicle
s_sold"])*100
df=df.groupby(["state","vehicle_category"],as_index=False)
["penetration_rate"].mean().sort_values(by="penetration_rate",ascendin
g=False).head(5)
```

```
df
#display(["fiscal_year"])
```

	state	vehicle_category	penetration_rate
17	Kerala	4-Wheelers	42.309117
6	Chandigarh	4-Wheelers	4.914759
10	Goa	4-Wheelers	4.369512
16	Karnataka	4-Wheelers	4.277313
9	Delhi	4-Wheelers	4.263585

```
#plot pie graph
plt.figure(figsize=(3, 3))
plt.pie(df["penetration_rate"], labels=df["state"], autopct='%1.1f%%',
startangle=140, colors=sns.color_palette("pastel"))
plt.title("Top 5 States by Penetration Rate of 2-Wheelers in FY 2024")
plt.axis('equal')  # Equal aspect ratio ensures that pie is drawn as a
circle.
plt.show()
```



Question 3: List the states with negative penetration (decline) in EV sales from 2022 to 2024

```
#penetration rate for fiscal year 2022

df=pd.merge(left=df_date,right=df_sales,on="date",how="inner")
df_2022 = df.loc[df["fiscal_year"] == 2022].copy()
df_2022["penetration_rate"] = (df_2022["electric_vehicles_sold"] /
df_2022["total_vehicles_sold"]) * 100
df_2022
```

	date	fiscal_year	quarter	state	\
0	2021-04-01	2022	Q1	Sikkim	
1	2021-04-01	2022	Q1	Sikkim	

```
2   2021-04-01         2022      Q1  Andaman & Nicobar Island
3   2021-04-01         2022      Q1         Arunachal Pradesh
4   2021-04-01         2022      Q1         Arunachal Pradesh
..         ...          ...     ...                       ...
810 2022-03-01         2022      Q4                Tamil Nadu
811 2022-03-01         2022      Q4                   Tripura
812 2022-03-01         2022      Q4             Uttar Pradesh
813 2022-03-01         2022      Q4               Uttarakhand
814 2022-03-01         2022      Q4               West Bengal

    vehicle_category  electric_vehicles_sold  total_vehicles_sold  \
0          2-Wheelers                       0                  398
1          4-Wheelers                       0                  361
2          2-Wheelers                       0                  515
3          2-Wheelers                       0                 1256
4          4-Wheelers                       0                  724
..                ...                     ...                  ...
810        2-Wheelers                    7708               124272
811        2-Wheelers                      18                 3504
812        2-Wheelers                    1986               180927
813        2-Wheelers                     435                11692
814        2-Wheelers                     626                73783

     penetration_rate
0            0.000000
1            0.000000
2            0.000000
3            0.000000
4            0.000000
..                ...
810          6.202523
811          0.513699
812          1.097680
813          3.720493
814          0.848434

[815 rows x 8 columns]
```

```
#penetration rate for fiscal year 2023
df=pd.merge(left=df_date,right=df_sales,on="date",how="inner")
df_2023 = df.loc[df["fiscal_year"] == 2023].copy()
df_2023["penetration_rate"] = (df_2023["electric_vehicles_sold"] /
df_2023["total_vehicles_sold"]) * 100
df_2023
```

```
           date  fiscal_year quarter                       state  \
815  2022-04-01         2023      Q1                      Sikkim
816  2022-04-01         2023      Q1                      Sikkim
817  2022-04-01         2023      Q1  Andaman & Nicobar Island
```

```
818  2022-04-01         2023      Q1         Arunachal Pradesh
819  2022-04-01         2023      Q1         Arunachal Pradesh
...         ...          ...     ...                       ...
1626 2023-03-01         2023      Q4                Tamil Nadu
1627 2023-03-01         2023      Q4                   Tripura
1628 2023-03-01         2023      Q4             Uttar Pradesh
1629 2023-03-01         2023      Q4               Uttarakhand
1630 2023-03-01         2023      Q4               West Bengal

     vehicle_category  electric_vehicles_sold  total_vehicles_sold  \
815         2-Wheelers                       0                  455
816         4-Wheelers                       0                  380
817         2-Wheelers                       0                  407
818         2-Wheelers                       0                 1063
819         4-Wheelers                       0                  824
...                ...                     ...                  ...
1626        2-Wheelers                    8388               119376
1627        2-Wheelers                      23                 3016
1628        2-Wheelers                    3559               206315
1629        2-Wheelers                     587                13077
1630        2-Wheelers                    1103                73690

      penetration_rate
815           0.000000
816           0.000000
817           0.000000
818           0.000000
819           0.000000
...                ...
1626          7.026538
1627          0.762599
1628          1.725032
1629          4.488797
1630          1.496811

[816 rows x 8 columns]
```

```
#penetration rate for fiscal year 2024
df=pd.merge(left=df_date,right=df_sales,on="date",how="inner")
df_2024 = df.loc[df["fiscal_year"] == 2024].copy()
df_2024["penetration_rate"] = (df_2024["electric_vehicles_sold"] /
df_2024["total_vehicles_sold"]) * 100
df_2024
```

```
           date  fiscal_year quarter                     state  \
1631 2023-04-01         2024      Q1                    Sikkim
1632 2023-04-01         2024      Q1                    Sikkim
1633 2023-04-01         2024      Q1  Andaman & Nicobar Island
1634 2023-04-01         2024      Q1         Arunachal Pradesh
```

```
1635 2023-04-01         2024      Q1                    Ladakh
...         ...          ...     ...                      ...
2440 2024-03-01         2024      Q4                   Mizoram
2441 2024-03-01         2024      Q4                DNH and DD
2442 2024-03-01         2024      Q4                   Manipur
2443 2024-03-01         2024      Q4  Andaman & Nicobar Island
2444 2024-03-01         2024      Q4                  Nagaland

     vehicle_category  electric_vehicles_sold  total_vehicles_sold  \
1631       2-Wheelers                       0                  465
1632       4-Wheelers                       0                  439
1633       2-Wheelers                       0                  325
1634       2-Wheelers                       0                  971
1635       2-Wheelers                       0                   43
...               ...                     ...                  ...
2440       2-Wheelers                      58                 1932
2441       2-Wheelers                      25                  780
2442       2-Wheelers                      13                 1394
2443       2-Wheelers                       2                  447
2444       2-Wheelers                       2                 1180

      penetration_rate
1631          0.000000
1632          0.000000
1633          0.000000
1634          0.000000
1635          0.000000
...                ...
2440          3.002070
2441          3.205128
2442          0.932568
2443          0.447427
2444          0.169492

[814 rows x 8 columns]
```

```
#states with negative penetration rates from 2022 to 2024
df=

array([], dtype=object)

# List the states with negative penetration (decline) in EV sales from
2022 to 2024 and also from 2023 to 2024

# Group by state and get mean penetration rate for each year
pen_2022 = df_2022.groupby("state", as_index=False)
["penetration_rate"].mean()
pen_2023 = df_2023.groupby("state", as_index=False)
["penetration_rate"].mean()
pen_2024 = df_2024.groupby("state", as_index=False)
```

```
["penetration_rate"].mean()

# Merge penetration rates for all years
pen_compare = pen_2022.merge(pen_2023, on="state", suffixes=('_2022',
'_2023'))
pen_compare = pen_compare.merge(pen_2024, on="state")
pen_compare = pen_compare.rename(columns={"penetration_rate":
"penetration_rate_2024"})

# States with decline from 2022 to 2024
negative_2022_2024 = pen_compare[pen_compare["penetration_rate_2024"]
< pen_compare["penetration_rate_2022"]]

# States with decline from 2023 to 2024
negative_2023_2024 = pen_compare[pen_compare["penetration_rate_2024"]
< pen_compare["penetration_rate_2023"]]

print("States with negative penetration from 2022 to 2024:")
print(negative_2022_2024[["state", "penetration_rate_2022",
"penetration_rate_2024"]])

print("\nStates with negative penetration from 2023 to 2024:")
print(negative_2023_2024[["state", "penetration_rate_2023",
"penetration_rate_2024"]])
```

```
States with negative penetration from 2022 to 2024:
                       state  penetration_rate_2022
penetration_rate_2024
0   Andaman & Nicobar Island               0.648338
0.592370
17                    Ladakh               2.638889
2.014572

States with negative penetration from 2023 to 2024:
               state  penetration_rate_2023  penetration_rate_2024
11           Haryana               1.742475               1.472185
12  Himachal Pradesh               0.877833               0.837345
32       Uttarakhand               2.331269               2.155752
```

Question 4: What are the quarterly trends based on sales volume for the top 5 EV makers (4-wheelers) from 2022 to 2024?

```
#quaterly sales on top 5 ev makers from 2022 to 2024

df=pd.merge(left=df_date,right=df_makers,on="date",how="inner")
df = df[(df["vehicle_category"] == "4-Wheelers") &
(df["fiscal_year"].isin([2022, 2023, 2024]))]
top_makers = df.groupby("maker")
["electric_vehicles_sold"].sum().sort_values(ascending=False).head(5).
index.tolist()
```

```
# Filter for top 5 makers
#df_top = df[df["maker"].isin(top_makers)]
#df_top
top_makers
```

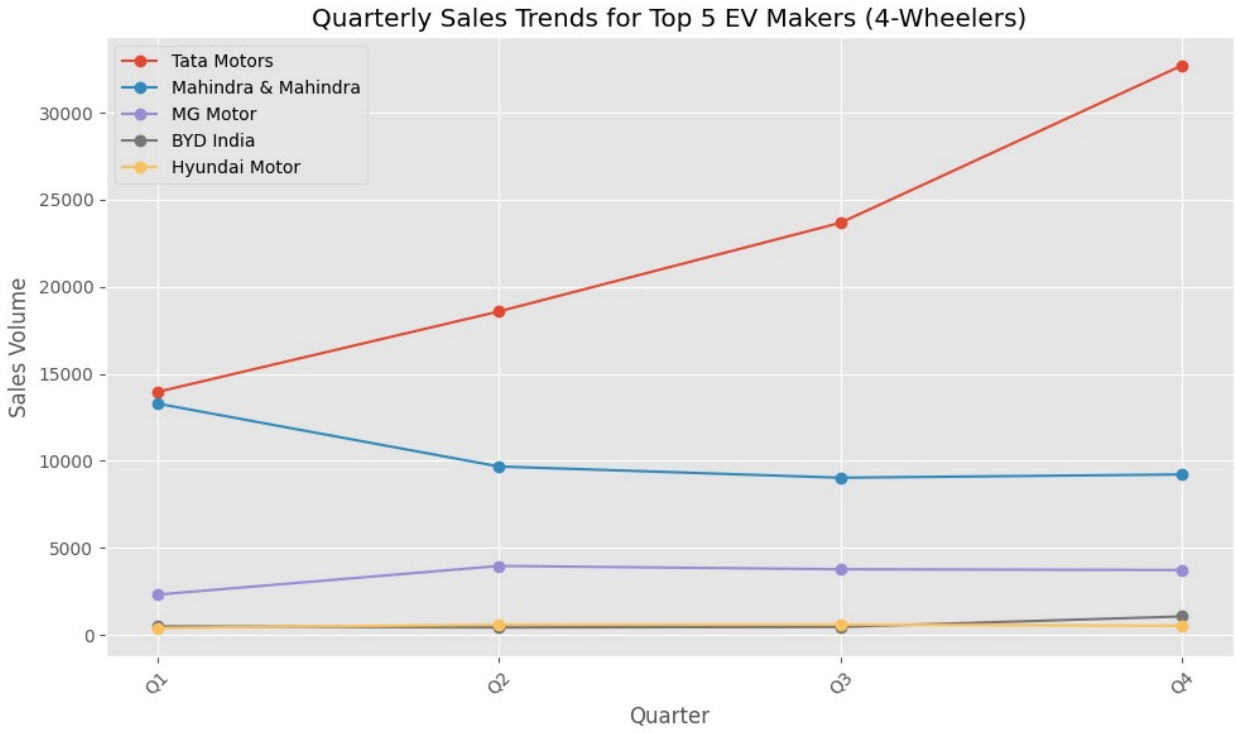
```
['Tata Motors',
 'Mahindra & Mahindra',
 'MG Motor',
 'BYD India',
 'Hyundai Motor']
```

```
# Filter for top 5 makers
df_top = df[df["maker"].isin(top_makers)]
#create quarter column
# Create quarter column using .loc
df_top.loc[:, "quarter"] #= df_top["date"].dt.to_period("Q")

# Group by maker and quarter to get quarterly sales
quarterly_sales = df_top.groupby(["maker", "quarter"])
["electric_vehicles_sold"].sum().reset_index().sort_values("quarter")
quarterly_sales
```

	maker	quarter	electric_vehicles_sold
0	BYD India	Q1	487
16	Tata Motors	Q1	13953
4	Hyundai Motor	Q1	392
12	Mahindra & Mahindra	Q1	13286
8	MG Motor	Q1	2309
17	Tata Motors	Q2	18581
13	Mahindra & Mahindra	Q2	9670
9	MG Motor	Q2	3957
5	Hyundai Motor	Q2	579
1	BYD India	Q2	423
6	Hyundai Motor	Q3	586
18	Tata Motors	Q3	23678
10	MG Motor	Q3	3766
14	Mahindra & Mahindra	Q3	9025
2	BYD India	Q3	454
11	MG Motor	Q4	3721
3	BYD India	Q4	1055
15	Mahindra & Mahindra	Q4	9212
7	Hyundai Motor	Q4	519
19	Tata Motors	Q4	32723

```
# Plot the sorted quarterly trends
plt.figure(figsize=(10, 6))
for maker in top_makers:
    maker_data = quarterly_sales[quarterly_sales["maker"] == maker]
    plt.plot(maker_data["quarter"].astype(str),
maker_data["electric_vehicles_sold"],
```

```
            marker='o', label=maker)

plt.title("Quarterly Sales Trends for Top 5 EV Makers (4-Wheelers)")
plt.xlabel("Quarter")
plt.ylabel("Sales Volume")
plt.legend()
plt.xticks(rotation=45)
plt.grid(True)
plt.tight_layout()
plt.show()
```



Queston 5: How do the EV sales and penetration rates in Delhi compare to Karnataka for 2024?

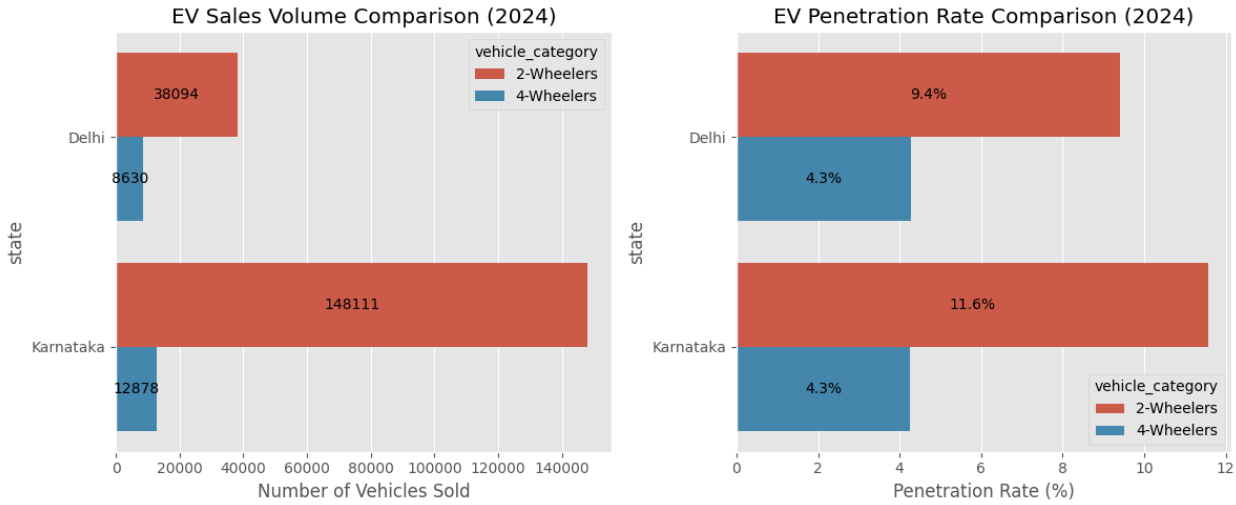
```
#EV sales and penetration rates in delhi compared to Karnataka for
2024

df = pd.merge(left=df_date, right=df_sales, on="date", how="inner")
#filter for 2024
df_2024 = df[df["fiscal_year"] == 2024]

#compare for delhi and karnataka
states_compare = df_2024[df_2024["state"].isin(["Delhi",
"Karnataka"])]

# Calculate metrics by state and vehicle category
comparison = states_compare.groupby(["state",
"vehicle_category"]).agg({
```

```
    "electric_vehicles_sold": "sum",
    "total_vehicles_sold": "sum"
}).reset_index()

# Calculate penetration rate
comparison["penetration_rate"] = (comparison["electric_vehicles_sold"]
/ comparison["total_vehicles_sold"]) * 100

#print detailed comparison
print(comparison.round(2))
```

```
       state vehicle_category  electric_vehicles_sold
total_vehicles_sold  \
0      Delhi       2-Wheelers                   38094
405218
1      Delhi       4-Wheelers                    8630
201130
2  Karnataka       2-Wheelers                  148111
1279767
3  Karnataka       4-Wheelers                   12878
302221

   penetration_rate
0              9.40
1              4.29
2             11.57
3              4.26
```

```
# Plot comparison with horizontal bars
plt.figure(figsize=(12, 5))

# Create subplot for sales volume
plt.subplot(1, 2, 1)
ax1 = sns.barplot(data=comparison,
                  y="state",
                  x="electric_vehicles_sold",
                  hue="vehicle_category",
                  orient="h")
# Add value labels in center of bars
for container in ax1.containers:
    ax1.bar_label(container, label_type='center', fmt='%.0f')
plt.title("EV Sales Volume Comparison (2024)")
plt.xlabel("Number of Vehicles Sold")

# Create subplot for penetration rates
plt.subplot(1, 2, 2)
ax2 = sns.barplot(data=comparison,
                  y="state",
                  x="penetration_rate",
                  hue="vehicle_category",
```

```
                  orient="h")
# Add percentage labels in center of bars
for container in ax2.containers:
    ax2.bar_label(container, label_type='center', fmt='%.1f%%')
plt.title("EV Penetration Rate Comparison (2024)")
plt.xlabel("Penetration Rate (%)")

plt.tight_layout()
plt.show()
```



Question 6:List down the compounded annual growth rate (CAGR) in 4-wheeler units for the top 5 makers from 2022 to 2024.

```
#find number of 4_wheelers sold in fiscal year 2024
df_2024=pd.merge(left=df_date, right=df_makers, on="date",
how="inner")
df_2024 = df_2024[(df_2024["fiscal_year"] ==
2024)&(df_2024["vehicle_category"] =="4-Wheelers")]
df_2024 = df_2024.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().rename(columns={"electric_vehicles_so
ld": "total_4_wheelers_sold"})
df_2024
```

	maker	total_4_wheelers_sold
0	BMW India	1078
1	BYD India	1466
2	Hyundai Motor	1390
3	KIA Motors	328
4	MG Motor	8829
5	Mahindra & Mahindra	23346
6	Mercedes -Benz AG	291
7	PCA Automobiles	1533

```
8          Tata Motors                    48181
9     Volvo Auto India                      459
```

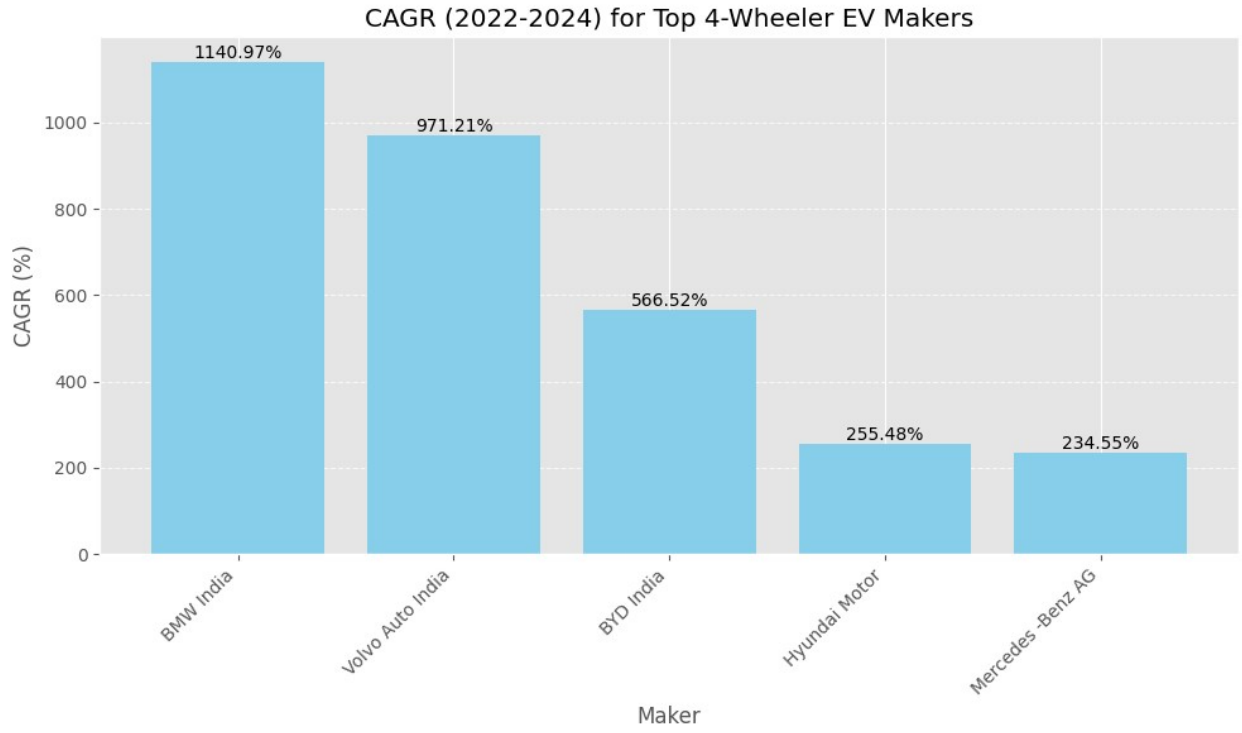
```
#find number of 4_wheelers sold in fiscal year 2022
df_2022=pd.merge(left=df_date, right=df_makers, on="date",
how="inner")
df_2022 = df_2022[(df_2022["fiscal_year"] ==
2022)&(df_2022["vehicle_category"] =="4-Wheelers")]
df_2022 = df_2022.groupby(["maker"],as_index=False)
["electric_vehicles_sold"].sum().rename(columns={"electric_vehicles_so
ld": "total_4_wheelers_sold"})
df_2022
```

```
                maker  total_4_wheelers_sold
0           BMW India                      7
1           BYD India                     33
2       Hyundai Motor                    110
3          KIA Motors                      0
4            MG Motor                   1647
5  Mahindra & Mahindra                  4042
6    Mercedes -Benz AG                    26
7      PCA Automobiles                     0
8          Tata Motors                 12708
9     Volvo Auto India                     4
```

```
#find CAGR(Compound Annual Growth Rate) from above 2 dataframes by top
5 makers

df=pd.merge(left=df_2022, right=df_2024, on="maker", how="inner")
df["CAGR"] = np.where(df["total_4_wheelers_sold_x"] == 0,  # Check for
zero 2022 sales
    0,  # Set CAGR to 0 if 2022 sales were 0
    np.round(((df["total_4_wheelers_sold_y"] /
df["total_4_wheelers_sold_x"]) ** (1/2) - 1) * 100, decimals=2)
)
df["CAGR"] = np.where(df["CAGR"] < 0, 0, df["CAGR"])  # Replace
negative CAGR with 0
df = df[df["CAGR"] > 0][["maker", "CAGR"]]
df = df.sort_values(by="CAGR", ascending=False).head(5)  # Get top 5
makers by CAGR

df
```

```
               maker     CAGR
0          BMW India  1140.97
9   Volvo Auto India   971.21
1          BYD India   566.52
2      Hyundai Motor   255.48
6  Mercedes -Benz AG   234.55
```

```
#plot grpah
# Plot CAGR comparison
plt.figure(figsize=(10, 6))
bars = plt.bar(df["maker"], df["CAGR"], color='skyblue')

# Add value labels on top of each bar
for bar in bars:
    height = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2., height,
             f'{height:.2f}%',
             ha='center', va='bottom')

plt.title("CAGR (2022-2024) for Top 4-Wheeler EV Makers")
plt.xlabel("Maker")
plt.ylabel("CAGR (%)")
plt.xticks(rotation=45, ha='right')
plt.grid(axis='y', linestyle='--', alpha=0.7)
plt.tight_layout()
plt.show()
```



Question 7:List down the top 10 states that had the highest compounded annual growth rate (CAGR) from 2022 to 2024 in total vehicles sold

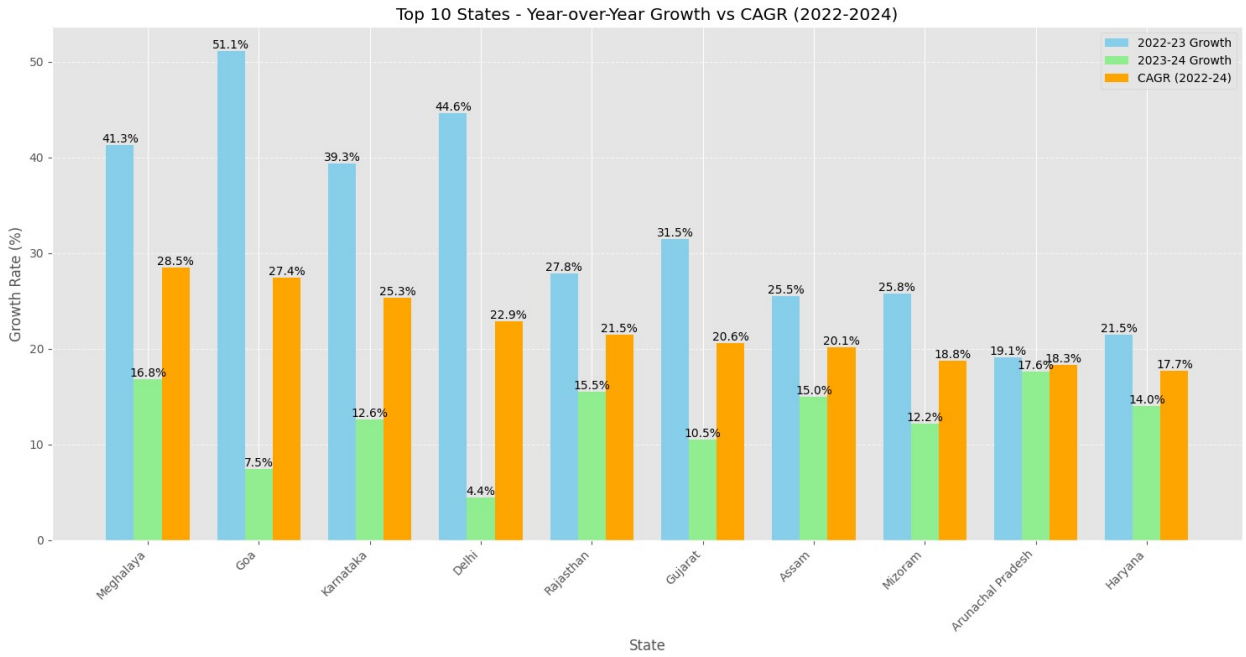
```
# Get total vehicles sold by state for all years
df = pd.merge(left=df_date, right=df_sales, on="date", how="inner")

# Calculate total vehicles for each year
```

```
df_2022 = df[df["fiscal_year"] == 2022].groupby("state")
["total_vehicles_sold"].sum().reset_index()
df_2022 = df_2022.rename(columns={"total_vehicles_sold":
"vehicles_2022"})

df_2023 = df[df["fiscal_year"] == 2023].groupby("state")
["total_vehicles_sold"].sum().reset_index()
df_2023 = df_2023.rename(columns={"total_vehicles_sold":
"vehicles_2023"})

df_2024 = df[df["fiscal_year"] == 2024].groupby("state")
["total_vehicles_sold"].sum().reset_index()
df_2024 = df_2024.rename(columns={"total_vehicles_sold":
"vehicles_2024"})

# Merge all years
df_cagr = df_2022.merge(df_2023, on="state").merge(df_2024,
on="state")

# Calculate year-over-year growth rates
df_cagr["growth_22_23"] =
((df_cagr["vehicles_2023"]/df_cagr["vehicles_2022"]) - 1) * 100
df_cagr["growth_23_24"] =
((df_cagr["vehicles_2024"]/df_cagr["vehicles_2023"]) - 1) * 100

# Calculate CAGR over entire period
df_cagr["CAGR"] =
np.round(((df_cagr["vehicles_2024"]/df_cagr["vehicles_2022"])**(1/2) -
1) * 100, 2)

# Get top 10 states by CAGR
top_10_states = df_cagr.nlargest(10, "CAGR")

top_10_states
```

	state	vehicles_2022	vehicles_2023	vehicles_2024	\
21	Meghalaya	22193	31362	36628	
9	Goa	48372	73074	78524	
15	Karnataka	1007894	1404447	1581988	
8	Delhi	401540	580548	606348	
27	Rajasthan	880985	1126130	1300476	
10	Gujarat	1094872	1439692	1590987	
3	Assam	379450	476195	547626	
22	Mizoram	19439	24446	27422	
2	Arunachal Pradesh	19929	23726	27892	
11	Haryana	528591	642148	732029	

	growth_22_23	growth_23_24	CAGR
21	41.314829	16.791021	28.47
9	51.066733	7.458193	27.41

```
15     39.344713     12.641346  25.28
8      44.580366      4.444077  22.88
27     27.826240     15.481872  21.50
10     31.494092     10.508845  20.55
3      25.496113     15.000367  20.13
22     25.757498     12.173771  18.77
2      19.052637     17.558796  18.30
11     21.482961     13.996929  17.68

# Create visualization
plt.figure(figsize=(15, 8))

# Plot yearly growth rates and CAGR
x = np.arange(len(top_10_states))
width = 0.25

plt.bar(x - width, top_10_states["growth_22_23"], width, label='2022-
23 Growth', color='skyblue')
plt.bar(x, top_10_states["growth_23_24"], width, label='2023-24
Growth', color='lightgreen')
plt.bar(x + width, top_10_states["CAGR"], width, label='CAGR (2022-
24)', color='orange')

# Add labels and formatting
plt.xlabel('State')
plt.ylabel('Growth Rate (%)')
plt.title('Top 10 States - Year-over-Year Growth vs CAGR (2022-2024)')
plt.xticks(x, top_10_states["state"], rotation=45, ha='right')
plt.legend()
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add value labels on bars
for i in x:
    plt.text(i - width, top_10_states["growth_22_23"].iloc[i],
             f'{top_10_states["growth_22_23"].iloc[i]:.1f}%',
             ha='center', va='bottom')
    plt.text(i, top_10_states["growth_23_24"].iloc[i],
             f'{top_10_states["growth_23_24"].iloc[i]:.1f}%',
             ha='center', va='bottom')
    plt.text(i + width, top_10_states["CAGR"].iloc[i],
             f'{top_10_states["CAGR"].iloc[i]:.1f}%',
             ha='center', va='bottom')

plt.tight_layout()
plt.show()
```

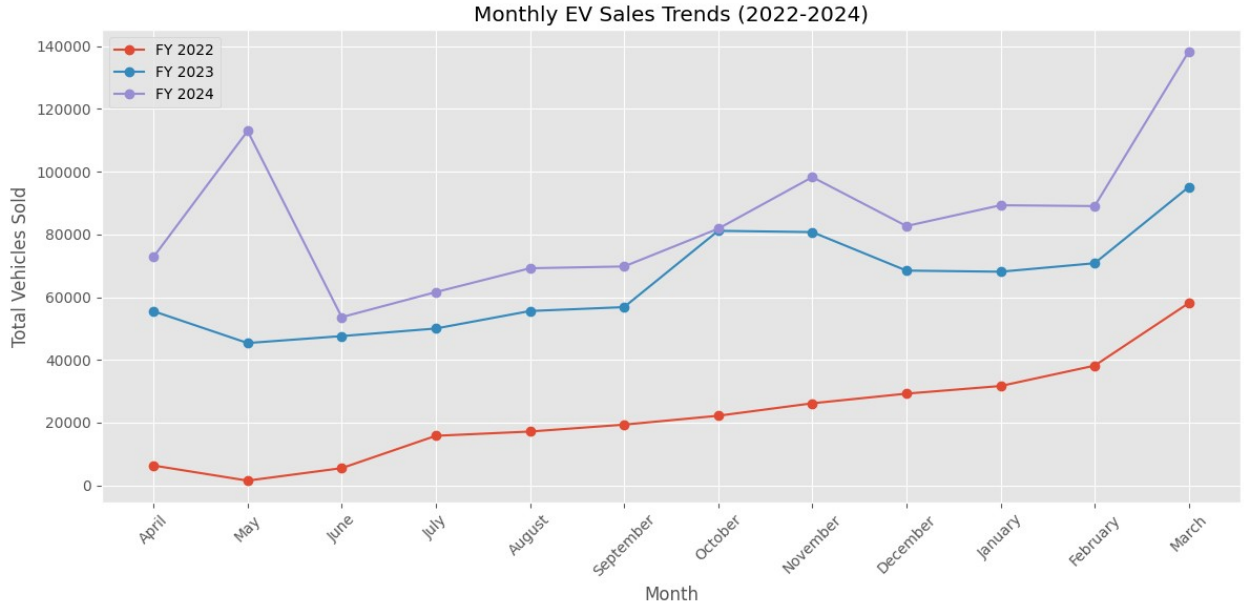


Question 8: What are the peak and low season months for EV sales based on the data from 2022 to 2024?

```
# Find peak and low season for each fiscal year
df = pd.merge(left=df_date, right=df_makers, on="date", how="inner")
df["month_name"] = df["date"].dt.month_name()

# Set month order for fiscal year (April to March)
month_order = ["April", "May", "June", "July", "August", "September",
               "October", "November", "December", "January",
"February", "March"]
df["month_name"] = pd.Categorical(df["month_name"],
categories=month_order, ordered=True)

# Group by fiscal year and month
monthly_sales = df.groupby(["fiscal_year", "month_name"],
as_index=False)["electric_vehicles_sold"].sum()

# Create pivot table
df_pivot = monthly_sales.pivot(index="month_name",
columns="fiscal_year", values="electric_vehicles_sold")
```

```
C:\Users\rushi\AppData\Local\Temp\ipykernel_8688\113023989.py:11:
FutureWarning: The default of observed=False is deprecated and will be
changed to True in a future version of pandas. Pass observed=False to
retain current behavior or observed=True to adopt the future default
and silence this warning.
  monthly_sales = df.groupby(["fiscal_year", "month_name"],
as_index=False)["electric_vehicles_sold"].sum()
```

```
# Plot monthly trends
plt.figure(figsize=(12, 6))
for year in df_pivot.columns:
    plt.plot(df_pivot.index, df_pivot[year], marker='o', label=f'FY
{year}')

plt.title("Monthly EV Sales Trends (2022-2024)")
plt.xlabel("Month")
plt.ylabel("Total Vehicles Sold")
plt.legend()
plt.grid(True)
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



question 9:What is the projected number of EV sales (including 2-wheelers and 4- wheelers) for the top 10 states by penetration rate in 2030, based on the compounded annual growth rate (CAGR) from previous years?

```
# Calculate current penetration rates and CAGR for each state
df = pd.merge(left=df_date, right=df_sales, on="date", how="inner")

# Get 2022 and 2024 data for CAGR calculation
df_2022 = df[df["fiscal_year"] == 2022].groupby("state")
[["electric_vehicles_sold", "total_vehicles_sold"]].sum()
df_2024 = df[df["fiscal_year"] == 2024].groupby("state")
[["electric_vehicles_sold", "total_vehicles_sold"]].sum()

# Calculate current penetration rate (2024)
df_2024["penetration_rate"] = (df_2024["electric_vehicles_sold"] /
```

```
df_2024["total_vehicles_sold"]) * 100

# Calculate CAGR (2022-2024)
combined = pd.merge(df_2022, df_2024, on="state", suffixes=('_2022',
'_2024'))
combined["CAGR"] = ((combined["electric_vehicles_sold_2024"] /
combined["electric_vehicles_sold_2022"]) ** (1/2) - 1) * 100

# Get top 10 states by penetration rate
top_10_states = combined.nlargest(10, "penetration_rate")

# Project sales for 2030 (6 years from 2024)
years_to_project = 6
top_10_states["projected_2030"] =
top_10_states["electric_vehicles_sold_2024"] * (1 +
top_10_states["CAGR"]/100) ** years_to_project

top_10_states
```

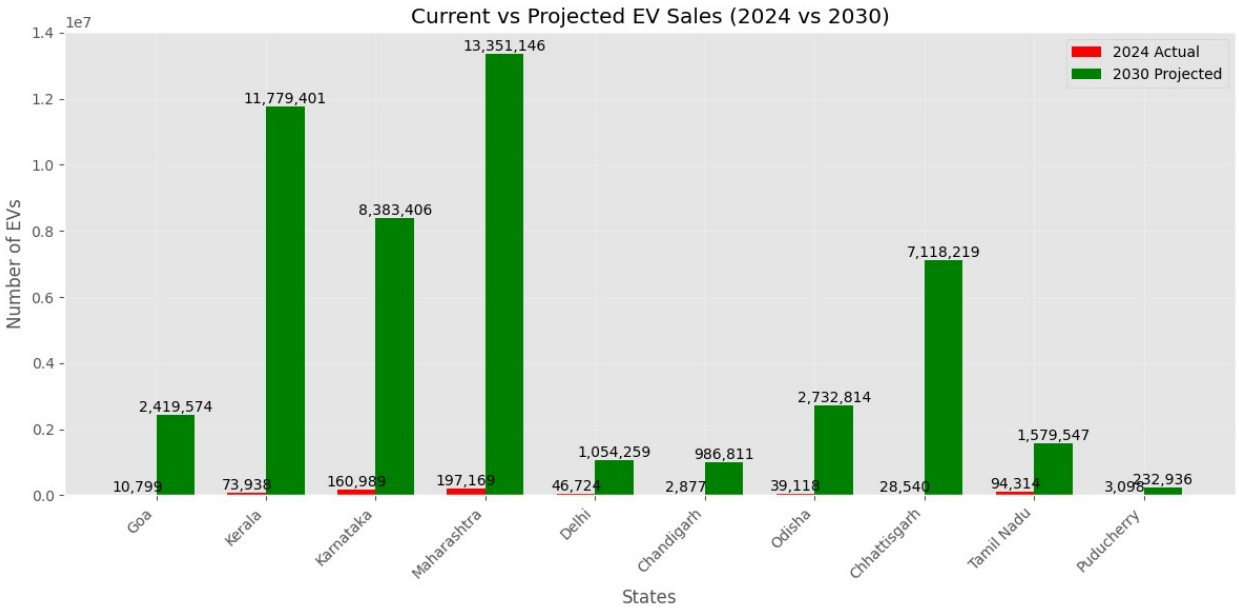
state	electric_vehicles_sold_2022	total_vehicles_sold_2022
Goa	1778	48372
Kerala	13639	689575
Karnataka	43111	1007894
Maharashtra	48374	1667002
Delhi	16535	401540
Chandigarh	411	36954
Odisha	9498	479527
Chhattisgarh	4534	390272
Tamil Nadu	36863	1345017
Puducherry	734	42945

state	electric_vehicles_sold_2024	total_vehicles_sold_2024
Goa	10799	78524
Kerala	73938	638114
Karnataka	160989	1581988
Maharashtra	197169	2293994
Delhi	46724	606348
Chandigarh	2877	45147
Odisha	39118	618149
Chhattisgarh	28540	503068
Tamil Nadu	94314	1716940
Puducherry	3098	57692

state	penetration_rate	CAGR	projected_2030
Goa	13.752483	146.448337	2.419574e+06
Kerala	11.586958	132.831955	1.177940e+07
Karnataka	10.176373	93.243125	8.383406e+06

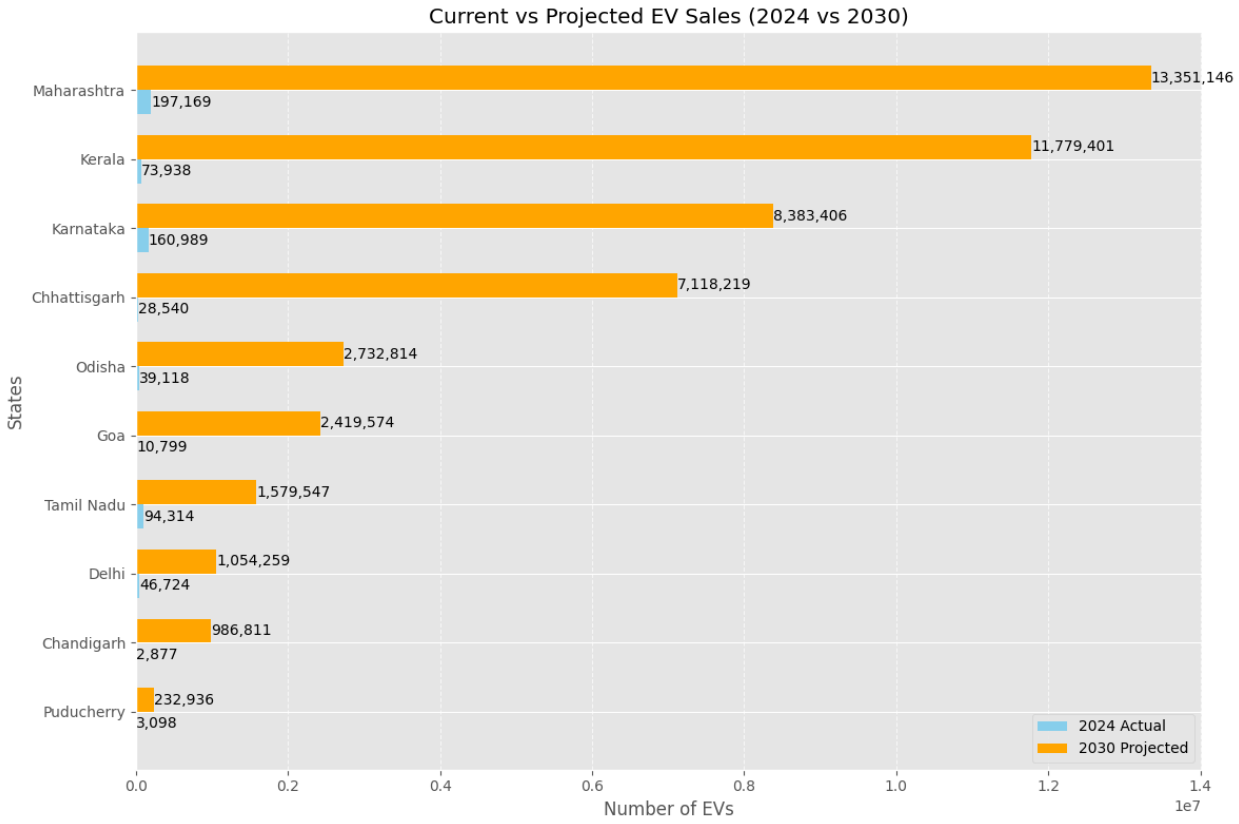
```
Maharashtra           8.595009  101.889307    1.335115e+07
Delhi                 7.705806   68.100075    1.054259e+06
Chandigarh            6.372516  164.575131    9.868110e+05
Odisha                6.328248  102.942141    2.732814e+06
Chhattisgarh          5.673189  150.891661    7.118219e+06
Tamil Nadu            5.493145   59.953130    1.579547e+06
Puducherry            5.369895  105.443628    2.329365e+05
```

```
# plot graph
plt.figure(figsize=(12, 6))
x = range(len(top_10_states.index))
width = 0.35

plt.bar(x, top_10_states["electric_vehicles_sold_2024"], width,
label="2024 Actual", color="red")
plt.bar([i + width for i in x], top_10_states["projected_2030"],
width, label="2030 Projected", color="green")

plt.xlabel("States")
plt.ylabel("Number of EVs")
plt.title("Current vs Projected EV Sales (2024 vs 2030)")
plt.xticks([i + width/2 for i in x], top_10_states.index, rotation=45,
ha='right')
plt.legend()

# Add value labels
for i, (current, projected) in
enumerate(zip(top_10_states["electric_vehicles_sold_2024"],

top_10_states["projected_2030"])):
    plt.text(i, current, f'{current:,.0f}', ha='center', va='bottom')
    plt.text(i + width, projected, f'{projected:,.0f}', ha='center',
va='bottom')

plt.grid(True, alpha=0.3)
plt.tight_layout()
plt.show()
```




```
# Create horizontal bar plot
plt.figure(figsize=(12, 8))

# Sort states by projected 2030 sales for better visualization
top_10_states_sorted = top_10_states.sort_values('projected_2030')

# Create horizontal bars
y = range(len(top_10_states_sorted.index))
plt.barh(y, top_10_states_sorted["electric_vehicles_sold_2024"],
         height=0.35, label="2024 Actual", color="skyblue")
plt.barh([i + 0.35 for i in y],
top_10_states_sorted["projected_2030"],
         height=0.35, label="2030 Projected", color="orange")

# Customize plot
plt.ylabel("States")
plt.xlabel("Number of EVs")
plt.title("Current vs Projected EV Sales (2024 vs 2030)")
plt.yticks([i + 0.175 for i in y], top_10_states_sorted.index)
plt.legend(loc='lower right')

# Add value labels
for i, (current, projected) in
enumerate(zip(top_10_states_sorted["electric_vehicles_sold_2024"],

top_10_states_sorted["projected_2030"])):
    plt.text(current, i, f'{current:,.0f}', va='center')
    plt.text(projected, i + 0.35, f'{projected:,.0f}', va='center')

plt.grid(axis='x', linestyle='--', alpha=0.7)
plt.tight_layout()
```

```
plt.show()
```


Current vs Projected EV Sales (2024 vs 2030)
Maharashtra
Kerala
Karnataka
Chhattisgarh
Odisha
Goa
Tamil Nadu
Delhi
Chandigarh
Puducherry
States
13,351,146
197,169
11,779,401
73,938
8,383,406
160,989
7,118,219
28,540
2,732,814
39,118
2,419,574
10,799
1,579,547
94,314
1,054,259
46,724
986,811
2,877
232,936
3,098
2024 Actual
2030 Projected
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1e7
Number of EVs