Analyze Customer Behavior & Evaluate Marketing Campaign Performance Using Sample Data

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Date : December 3, 2025

1. Dataset Overview

This project utilizes two datasets: one containing customer purchase data including Customer ID, Order Date, Order Amount, and Product Category; and a marketing campaign dataset with Campaign ID, Impressions, Clicks, Conversions, Spend, Revenue, and Campaign Dates. The datasets span multiple months and include key metrics essential for analysis of customer behavior and campaign performance

2. **Data Cleaning Summary**

- Removed duplicate records and standardized categorical fields for consistency.
- Corrected date formats for analysis accuracy.
- Removed entries with negative or zero values in critical fields such as Purchase Amount, Spend, or Clicks.
- Handled missing values by imputation or removal as appropriate.
- Recalculated analytical metrics like CTR and Conversion Rate from raw data for reliability.

3. **Customer Metrics (Part A)**

- **Most Active Customers:** Identified top buyers by number of orders and revenue contribution.
- **Buying Frequency**: Calculated average time between purchases and monthly order trends.
- **Customer Retention**: Analyzed new vs returning customers, retention rates, and churn patterns.
- **Revenue Contribution**: Used Pareto analysis to segment high-value customers accounting for 80% of revenue.

4. Campaign Metrics (Part B)

- **CTR (Click-Through Rate)**: Measured percentage of ad impressions leading to clicks.
- **Conversion Rate**: Percentage of clicks resulting in conversions.

- **Cost Per Lead (CPL)**: Spend divided by number of conversions, indicating acquisition cost efficiency.
- **Return on Investment (ROI)**: Percentage return comparing revenue to campaign spend.
- **Customer Acquisition Cost (CAC)**: Calculated where new customer data available, dividing total spend by new customers acquired.

5. Charts & Visualizations

- Bar chart presenting top 10 customers by revenue.
- Line chart showing monthly order frequency trends.
- Pie chart depicting customer segments based on revenue contribution.
- Retention heatmap illustrating customer retention by month.
- Bar charts displaying top campaigns by CTR and Conversion Rate.
- Scatter plot of campaign spend versus revenue visualizing ROI.
- Optional ROI trends bar chart for campaign prioritization.

6. Insights & Recommendations

- A small segment of high-value customers drives most revenue, warranting personalized targeting and retention efforts.
- Seasonal peaks in purchase frequency advise timing marketing pushes.
- Campaigns with high CTR but low conversion require funnel optimization or retargeting.
- Budget reallocation recommended from low ROI campaigns to top performers.
- Cost-effective campaigns with low CPL represent efficient acquisition channels.
- New customer acquisition data should be integrated for CAC analysis to enhance profitability evaluation
- Campaign length and creative formats should be tested for optimal engagement.
- Device- and channel-based segmentation can further optimize targeting.
- Improving funnel steps and reducing churn can improve long-term customer value.
- Continuous dashboard monitoring is advised for agile marketing decisions.
- Choose 10 small campaigns over a 1 big campaign , because small campaigns help us to reach the ground level peoples.

7. Tools Used

- Python (pandas, matplotlib, seaborn) for data cleaning, analysis, and visualization.

PART-A Customer Behavior Analysis

Data Loading and *Cleaning*

```
import pandas as pd

# Load dataset
data = pd.read_csv('/content/drive/MyDrive/Colab Notebooks/project/Ecommerce_Cc

# Remove duplicates
data = data.drop_duplicates()

# Fill missing values in 'Engagement_with_Ads' with 'Unknown'
data['Engagement_with_Ads'] = data['Engagement_with_Ads'].fillna('Unknown')

# Convert purchase date to datetime format
data['Time_of_Purchase'] = pd.to_datetime(data['Time_of_Purchase'], errors='coe

# Remove invalid purchase amounts (non-positive values)
data['Purchase_Amount'] = data['Purchase_Amount'].replace('[$,]', '', regex=Tru
data = data[data['Purchase_Amount'] > 0]

# Standardize categorical fields
data['Gender'] = data['Gender'].str.capitalize()
data['Payment_Method'] = data['Payment_Method'].str.capitalize()
data['Purchase_Intent'] = data['Purchase_Intent'].str.capitalize()

# Checking the info of columns
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 28 columns):
 #   Column                                Non-Null Count  Dtype
---  ------                                --------------  -----
 0   Customer_ID                           1000 non-null   object
 1   Age                                   1000 non-null   int64
 2   Gender                                1000 non-null   object
 3   Income_Level                          1000 non-null   object
 4   Marital_Status                        1000 non-null   object
 5   Education_Level                       1000 non-null   object
 6   Occupation                            1000 non-null   object
 7   Location                              1000 non-null   object
 8   Purchase_Category                     1000 non-null   object
 9   Purchase_Amount                       1000 non-null   float64
 10  Frequency_of_Purchase                 1000 non-null   int64
 11  Purchase_Channel                      1000 non-null   object
 12  Brand_Loyalty                         1000 non-null   int64
 13  Product_Rating                        1000 non-null   int64
 14  Time_Spent_on_Product_Research(hours) 1000 non-null   float64
 15  Social_Media_Influence                753 non-null    object
 16  Discount_Sensitivity                  1000 non-null   object
 17  Return_Rate                           1000 non-null   int64
 18  Customer_Satisfaction                 1000 non-null   int64
 19  Engagement_with_Ads                   1000 non-null   object
 20  Device_Used_for_Shopping              1000 non-null   object
 21  Payment_Method                        1000 non-null   object
 22  Time_of_Purchase                      1000 non-null   datetime64[ns]
 23  Discount_Used                         1000 non-null   bool
 24  Customer_Loyalty_Program_Member       1000 non-null   bool
 25  Purchase_Intent                       1000 non-null   object
 26  Shipping_Preference                   1000 non-null   object
 27  Time_to_Decision                      1000 non-null   int64
dtypes: bool(2), datetime64[ns](1), float64(2), int64(7), object(16)
memory usage: 205.2+ KB
```

Most Active Customers

```
# Number of orders per customer
orders_per_customer = data.groupby('Customer_ID').size().sort_values(ascending=

# Top 10 most frequent buyers
top_10_buyers = orders_per_customer.head(10)

print(top_10_buyers)
```

```
Customer_ID
99-945-7193    1
00-107-4749    1
00-149-4481    1
00-264-3797    1
00-265-0556    1
00-275-9990    1
00-285-9607    1
00-335-5034    1
97-738-8095    1
97-715-3606    1
dtype: int64
```

High-value vs Low-value **Customers**

```
# Total revenue per customer
revenue_per_customer = data.groupby('Customer_ID')['Purchase_Amount'].sum().sor

# Define high-value customers as top 20% by revenue
high_value_threshold = revenue_per_customer.quantile(0.8)
high_value_customers = revenue_per_customer[revenue_per_customer >= high_value_
low_value_customers = revenue_per_customer[revenue_per_customer < high_value_th

print(f'High-value customers count: {len(high_value_customers)}')
print(f'Low-value customers count: {len(low_value_customers)}')
```

```
High-value customers count: 200
Low-value customers count: 800
```

Customer Retention Analysis

```
data['First_Order_Date'] = data.groupby('Customer_ID')['Time_of_Purchase'].trar
data['Order_Month'] = data['Time_of_Purchase'].dt.to_period('M')
data['First_Order_Month'] = data['First_Order_Date'].dt.to_period('M')

# New customer if order month == first order month, else returning
new_customers = data[data['Order_Month'] == data['First_Order_Month']]
returning_customers = data[data['Order_Month'] != data['First_Order_Month']]

new_customers_count = new_customers.groupby('Order_Month')['Customer_ID'].nunic
returning_customers_count = returning_customers.groupby('Order_Month')['Custome

retention_rate = returning_customers_count / (returning_customers_count + new_c

print(retention_rate)
```

```
Order_Month
2024-01   NaN
2024-02   NaN
2024-03   NaN
2024-04   NaN
2024-05   NaN
```

```
2024-06   NaN
2024-07   NaN
2024-08   NaN
2024-09   NaN
2024-10   NaN
2024-11   NaN
2024-12   NaN
Freq: M, Name: Customer_ID, dtype: float64
```

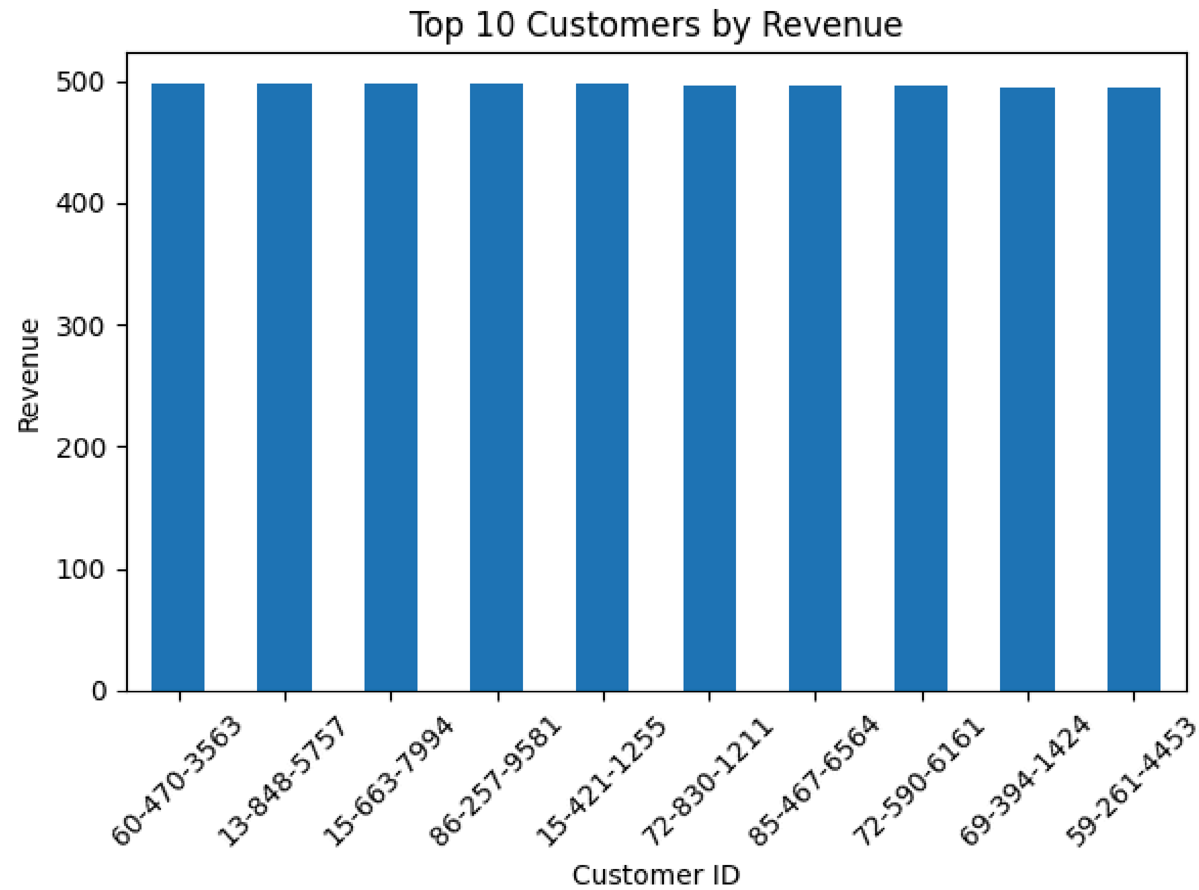
Revenue Contribution & Pareto Analysis

```
top_10_customers = revenue_per_customer.head(10)

cumulative_revenue = revenue_per_customer.cumsum()
total_revenue = revenue_per_customer.sum()
cumulative_percentage = cumulative_revenue / total_revenue

# Number of customers to reach 80% revenue
pareto_20_customers = cumulative_percentage[cumulative_percentage <= 0.8].count

print(f'Customers contributing to 80% revenue: {pareto_20_customers}')
```

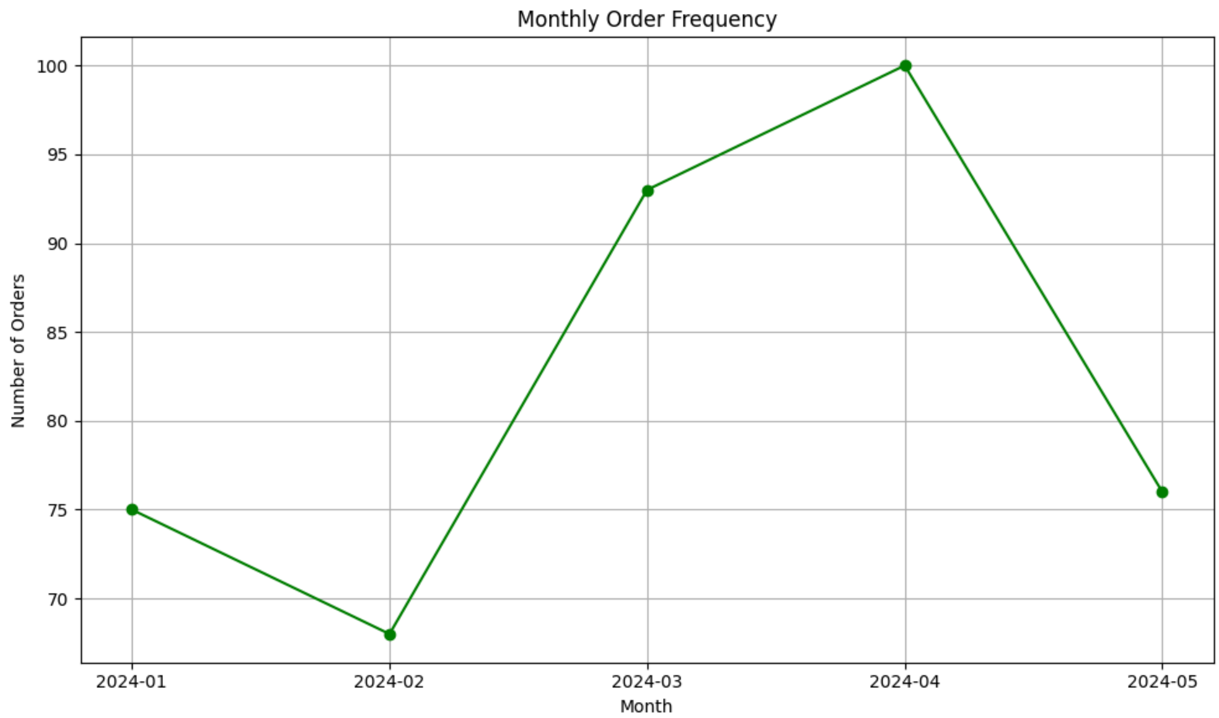
```
Customers contributing to 80% revenue: 601
```

Visualization

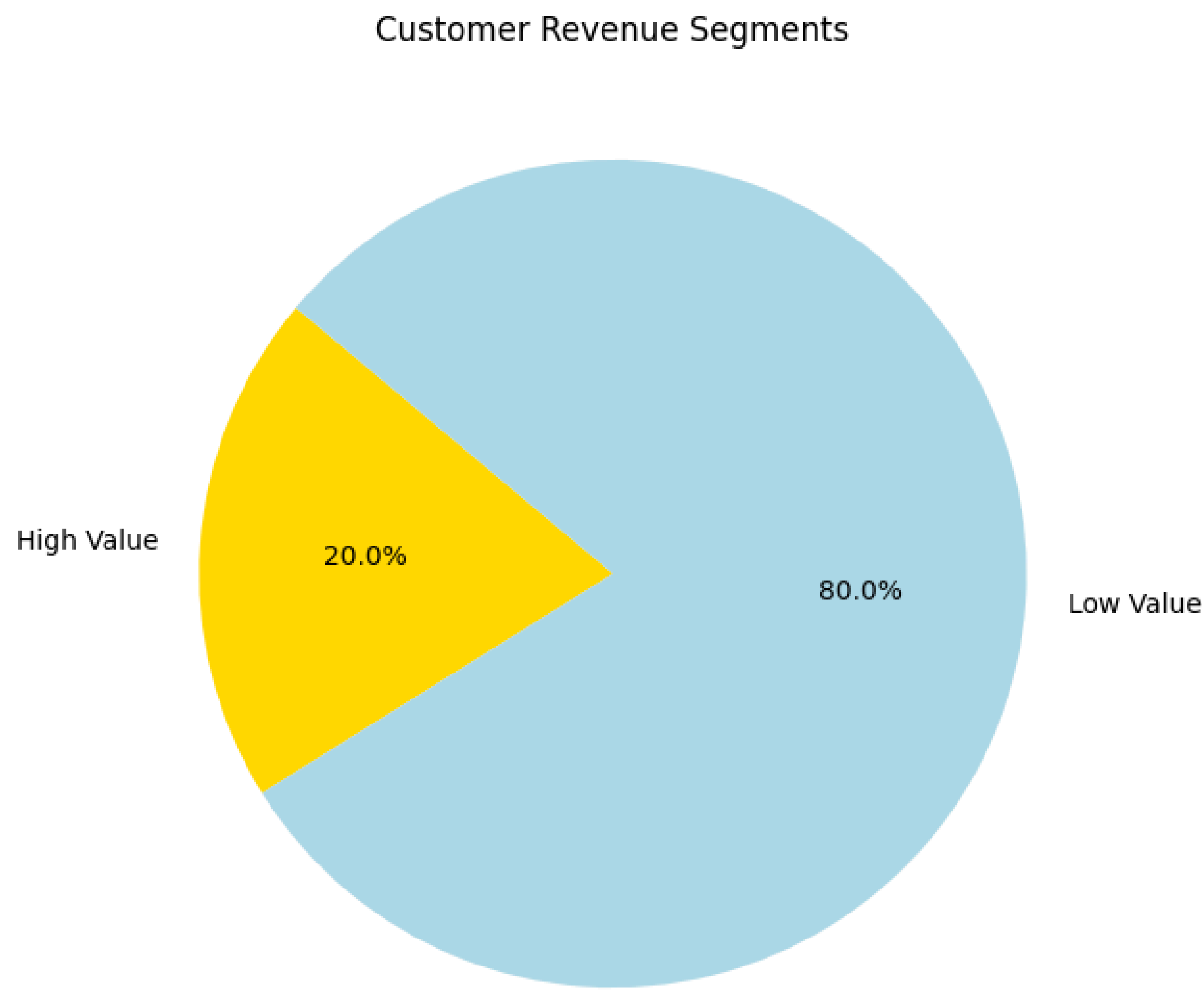
```
# Bar chart → revenue by customer

import matplotlib.pyplot as plt

top_10_customers.plot(kind='bar')
plt.title('Top 10 Customers by Revenue')
plt.xlabel('Customer ID')
plt.ylabel('Revenue')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



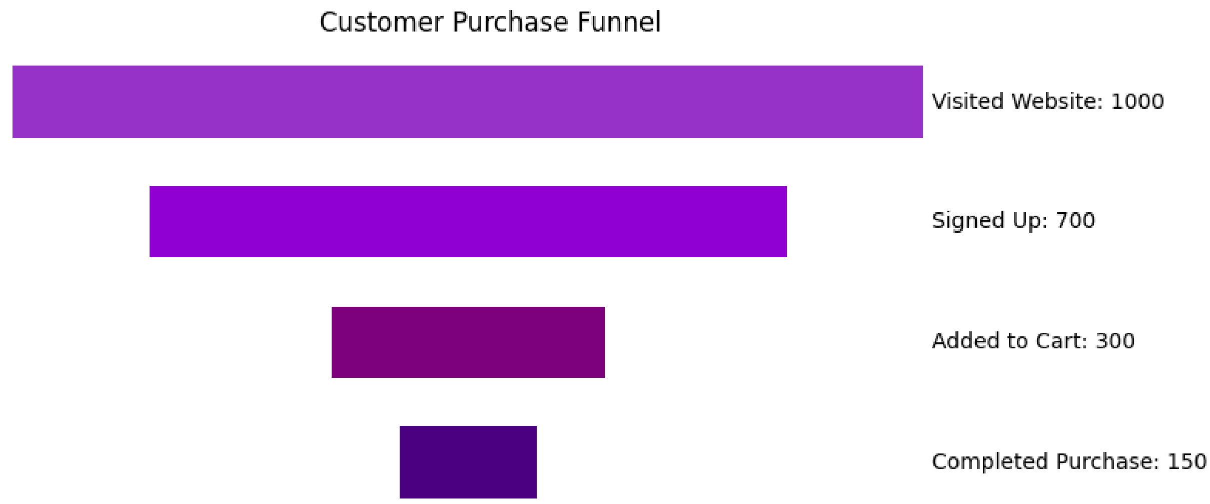

```python
# Line chart → frequency over time

# Monthly order counts from Jan to May 2024
months = ['2024-01', '2024-02', '2024-03', '2024-04', '2024-05']
orders = [75, 68, 93, 100, 76]

plt.figure(figsize=(10, 6))
plt.plot(months, orders, marker='o', linestyle='-', color='green')
plt.title('Monthly Order Frequency')
plt.xlabel('Month')
plt.ylabel('Number of Orders')
plt.grid(True)
plt.tight_layout()
plt.show()
```




```
# . Pie Chart: Customer Revenue Segments

# Customer segments count
segments = ['High Value', 'Low Value']
counts = [200, 800]

plt.figure(figsize=(7, 7))
plt.pie(counts, labels=segments, autopct='%1.1f%%', startangle=140, colors=['gc
plt.title('Customer Revenue Segments')
plt.show()
```

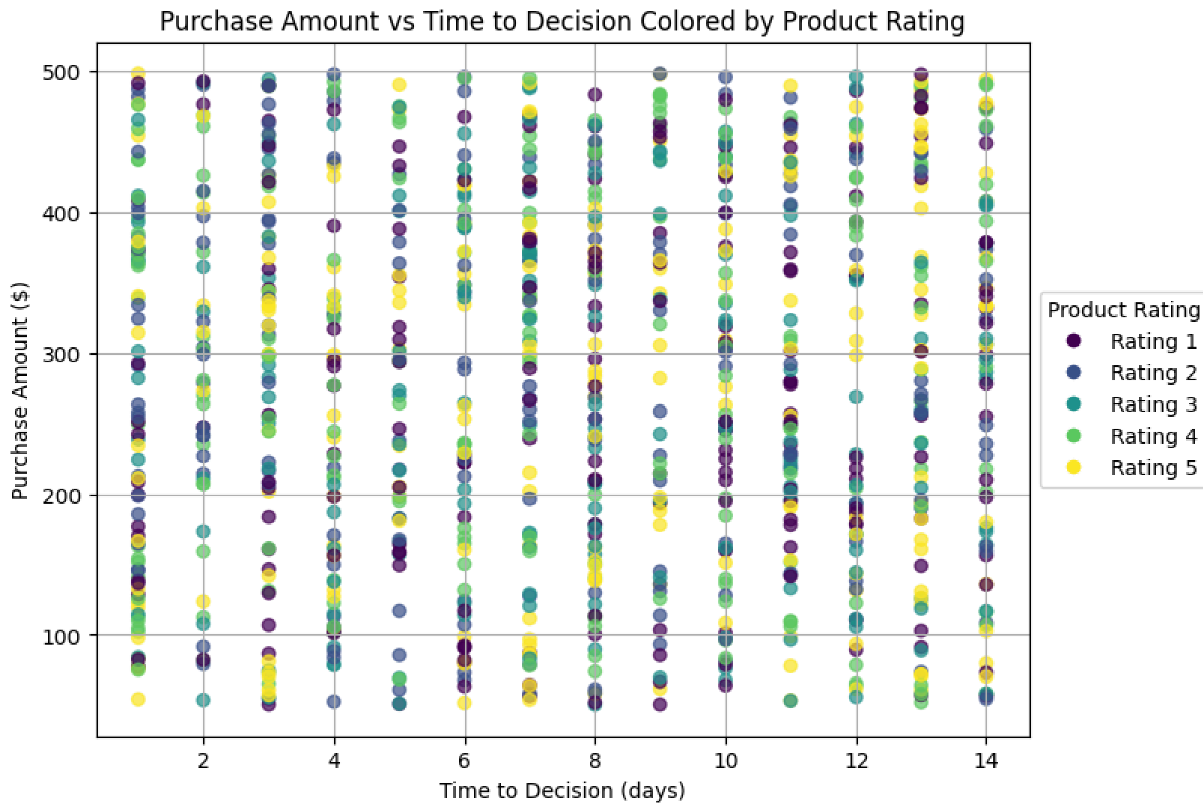



```
import pandas as pd
import matplotlib.pyplot as plt

def funnel_chart(df, show_n=True, show_pct='NA'):
    df['val'] = df['val'].astype(int)
    max_val = df['val'].max()
    df = df.sort_values('val', ascending=True).reset_index(drop=True)
    df['left'] = (max_val - df['val']) / 2
    colors = ['indigo', 'purple', 'darkviolet', 'darkorchid', 'mediumorchid', '

    fig, ax = plt.subplots(figsize=(8, 4))
    for i in range(len(df)):
        ax.barh(i, df.loc[i, 'val'], left=df.loc[i, 'left'], height=0.6,
                color=colors[i % len(colors)], label=df.loc[i, 'step'])
        if show_n:
            ax.text(max_val * 1.01, i, f"{df.loc[i, 'step']}: {df.loc[i, 'val']
    ax.axis('off')
    plt.title('Customer Purchase Funnel')
    plt.show()

# Example funnel data (you can create based on your dataset, e.g., signup -> br
funnel_data = pd.DataFrame({
    'step': ['Visited Website', 'Signed Up', 'Added to Cart', 'Completed Purcha
    'val': [1000, 700, 300, 150]
})

funnel_chart(funnel_data)
```




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

x = data['Time_to_Decision']
y = data['Purchase_Amount']
ratings = data['Product_Rating']
unique_ratings = sorted(ratings.unique())
colors = plt.cm.viridis(np.linspace(0, 1, len(unique_ratings)))
color_map = dict(zip(unique_ratings, colors))
point_colors = ratings.map(color_map)

fig, ax = plt.subplots(figsize=(10, 6))
scatter = ax.scatter(x, y, c=point_colors, alpha=0.7)
ax.set_xlabel('Time to Decision (days)')
ax.set_ylabel('Purchase Amount ($)')
ax.set_title('Purchase Amount vs Time to Decision Colored by Product Rating')
ax.grid(True)

# Shrink current axis width to make space for legend
box = ax.get_position()
ax.set_position([box.x0, box.y0, box.width * 0.8, box.height])

# Place legend outside the plot on the right-center
handles = [plt.Line2D([0], [0], marker='o', color='w', label=f'Rating {r}',
                      markerfacecolor=color_map[r], markersize=8) for r in unic
ax.legend(handles=handles, title='Product Rating', loc='center left', bbox_to_a

plt
```

```
<module 'matplotlib.pyplot' from '/usr/local/lib/python3.12/dist-
packages/matplotlib/pyplot.py'>
```



PART B — Marketing Campaign Performance Evaluation

Load and Inspect DataSet

```
import pandas as pd

# Load dataset
data = pd.read_csv('/content/drive/MyDrive/Colab Notebooks/project/final_shop_6

# Inspect columns and sample data
print(data.columns)
print(data.head())

# info
data.info()
```

```
Index(['Ad Group', 'Month', 'Impressions', 'Clicks', 'CTR', 'Conversions',
       'Conv Rate', 'Cost', 'CPC', 'Revenue', 'Sale Amount', 'P&L'],
      dtype='object')
                                    Ad Group Month  Impressions  Clicks   CTR  \
0    Shop - 1:1 - Desk - [shop coupon code]  July        16038    6504  0.41
1         Shop - 1:1 - Desk - [shop coupon]  July        36462   14367  0.39
2  Shop - 1:1 - Desk - [shop discount code]  July         3635    1458  0.40
3     Shop - 1:1 - Desk - [shop promo code]  July        26185   10418  0.40
4          Shop - 1:1 - Desk - [shop promo]  July          808     282  0.35

   Conversions  Conv Rate   Cost   CPC  Revenue  Sale Amount       P&L
0         1166       0.10   6669  1.03     6402    136770.05 -267.086
1         2188       0.09  13746  0.96    13262    283215.21 -483.951
```

```
2          248       0.09   1606  1.10     1723     39165.46  117.136
3         2294       0.12  13278  1.27    13042    284823.48 -235.921
4           61       0.15    391  1.39      337      7717.77  -53.604
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 190 entries, 0 to 189
Data columns (total 12 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   Ad Group     190 non-null    object 
 1   Month        190 non-null    object 
 2   Impressions  190 non-null    int64  
 3   Clicks       190 non-null    int64  
 4   CTR          190 non-null    float64
 5   Conversions  190 non-null    int64  
 6   Conv Rate    190 non-null    float64
 7   Cost         190 non-null    int64  
 8   CPC          190 non-null    float64
 9   Revenue      190 non-null    int64  
 10  Sale Amount  190 non-null    float64
 11  P&L          190 non-null    float64
dtypes: float64(5), int64(5), object(2)
memory usage: 17.9+ KB
```

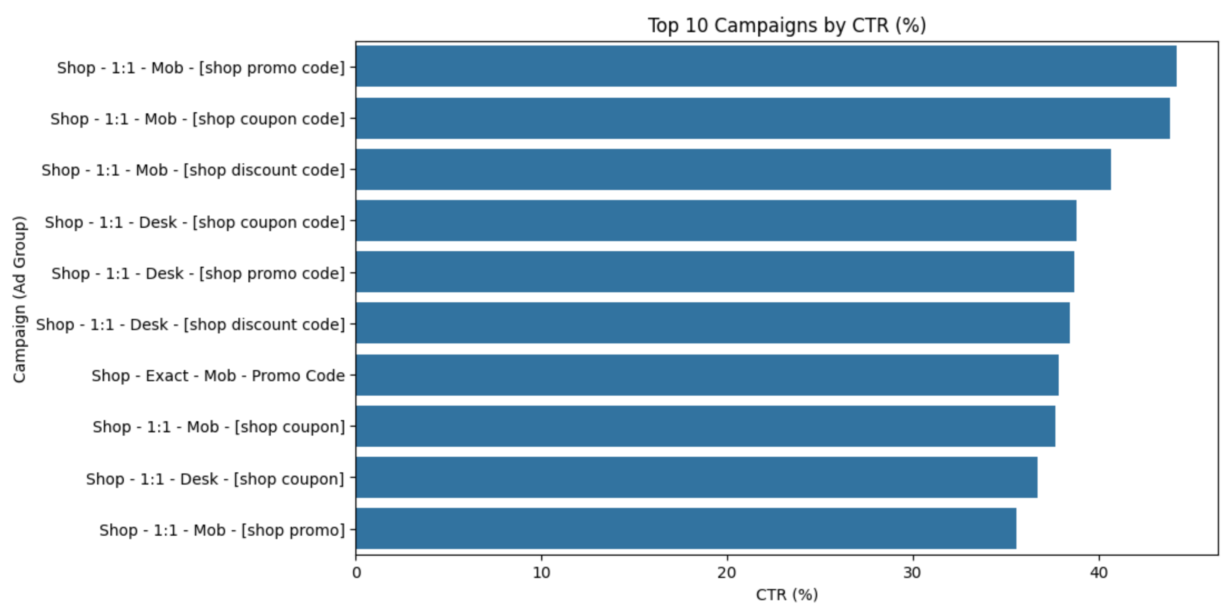
Data Cleaning and Preparation

```
# Check for missing values
print(data.isnull().sum())

# Filter out rows with zero or negative spend or clicks (invalid data)
data_clean = data[(data['Cost'] > 0) & (data['Clicks'] > 0) & (data['Conversior

# Calculate CTR (if missing or inconsistent)
data_clean['CTR_calc'] = (data_clean['Clicks'] / data_clean['Impressions']) * 1

# Calculate Conversion Rate (if missing or inconsistent)
data_clean['ConversionRate_calc'] = (data_clean['Conversions'] / data_clean['Cl

# Calculate Cost Per Lead (CPL)
data_clean['CPL'] = data_clean['Cost'] / data_clean['Conversions']

# Calculate Return on Investment (ROI) in percentage
data_clean['ROI'] = ((data_clean['Revenue'] - data_clean['Cost']) / data_clean[

# Note for CAC (Customer Acquisition Cost): Requires new customers data, not av

print(data_clean[['CTR_calc', 'ConversionRate_calc', 'CPL', 'ROI']].head())
```

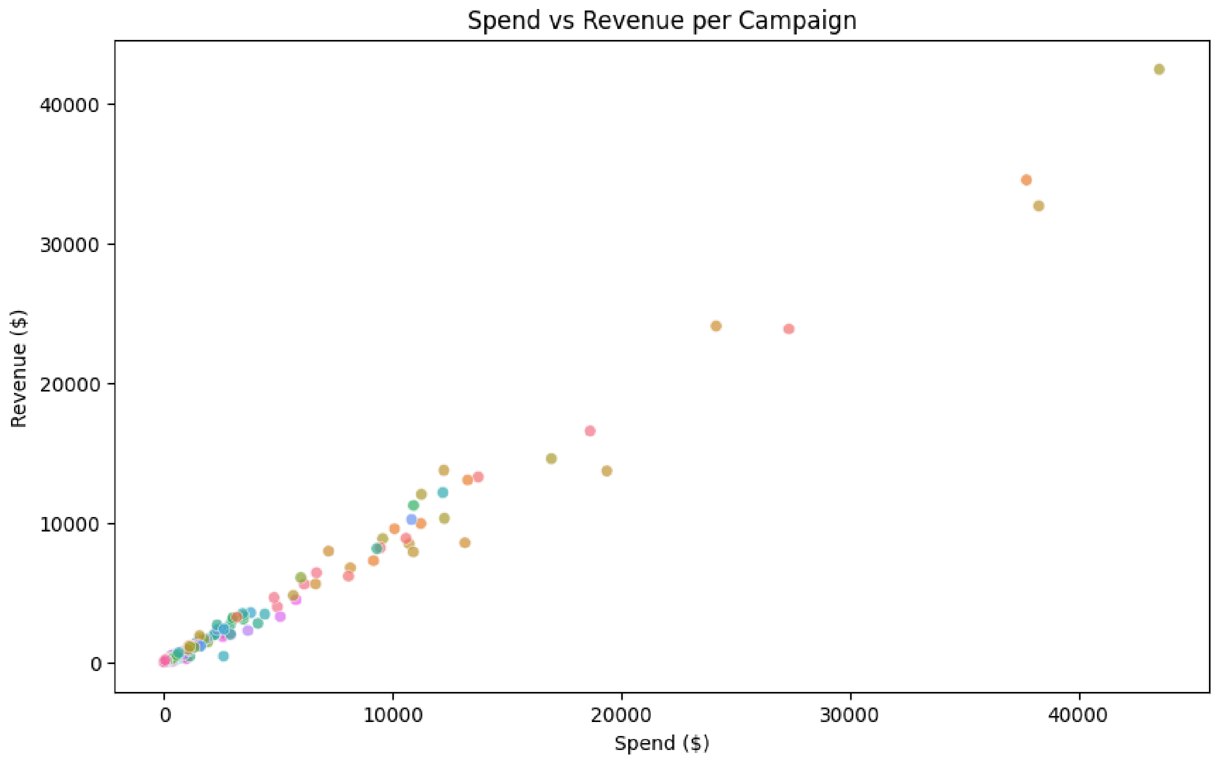
```
Ad Group       0
Month          0
Impressions    0
Clicks         0
CTR            0
Conversions    0
Conv Rate      0
Cost           0
CPC            0
Revenue        0
Sale Amount    0
P&L            0
dtype: int64
    CTR_calc  ConversionRate_calc       CPL        ROI
0  40.553685            17.927429  5.719554  -4.003599
1  39.402666            15.229345  6.282450  -3.521024
2  40.110041            17.009602  6.475806   7.285181
3  39.786137            22.019581  5.788143  -1.777376
4  34.900990            21.631206  6.409836 -13.810742
```

Visualizations

```
import matplotlib.pyplot as plt
import seaborn as sns

# A. CTR comparison across campaigns (top 10)
top_campaigns = data_clean.groupby('Ad Group')['CTR_calc'].mean().sort_values(a
plt.figure(figsize=(10,6))
sns.barplot(x=top_campaigns.values, y=top_campaigns.index)
plt.title("Top 10 Campaigns by CTR (%)")
plt.xlabel("CTR (%)")
plt.ylabel("Campaign (Ad Group)")
plt.show()
```




```
# B. Spend vs Revenue chart (scatter)
plt.figure(figsize=(10,6))
sns.scatterplot(data=data_clean, x='Cost', y='Revenue', hue='Ad Group', legend=
plt.title("Spend vs Revenue per Campaign")
plt.xlabel("Spend ($)")
plt.ylabel("Revenue ($)")
plt.show()
```




```
# C. Conversion rate bar chart for top 10 campaigns
top_conv_campaigns = data_clean.groupby('Ad Group')['ConversionRate_calc'].mean(
plt.figure(figsize=(10,6))
```