final

August 29, 2024

[2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

1 Question 1

[4]:
```
df = pd.read_csv("SeoulBikeData.csv")

# Remove non functioning Days
df = df[df['Functioning Day'] == 'Yes']

# select winter seasons
df =df[df["Seasons"] == "Winter"]
```

[5]:
```
# separate into snowfall and no snowfall data
df_snowfall = df[df["Snowfall (cm)"] > 0]
df_no_snowfall = df[df["Snowfall (cm)"] == 0]

print("Number of points with snowfall: ", len(df_snowfall))
print("Number of points with no snowfall: ", len(df_no_snowfall))
```

```
Number of points with snowfall:  392
Number of points with no snowfall:  1768
```

[6]:
```
# Average bike rentals during both seasons
mean_snowfall = df_snowfall["Rented Bike Count"].mean()
mean_noSnowfall = df_no_snowfall["Rented Bike Count"].mean()

print("Average bike rentals during snowfall: ", mean_snowfall)
print("Average bike rentals during no snowfall: ", mean_noSnowfall)
```

```
Average bike rentals during snowfall:  157.30357142857142
Average bike rentals during no snowfall:  240.670814479638
```

[8]:

```
sigmaSnowfall = 0

sigmaSnowfall = (df_snowfall["Rented Bike Count"] - mean_snowfall).pow(2).sum()
sigmaSnowfall = sigmaSnowfall / len(df_snowfall)

sigmaNoSnowfall = 0

sigmaNoSnowfall = (df_no_snowfall["Rented Bike Count"] - mean_noSnowfall).
 ↪pow(2).sum()
sigmaNoSnowfall = sigmaNoSnowfall / len(df_no_snowfall)

print("Standard deviation of bike rentals during snowfall: ", np.
 ↪sqrt(sigmaSnowfall))
print("Standard deviation of bike rentals during no snowfall: ", np.
 ↪sqrt(sigmaNoSnowfall))
```

```
Standard deviation of bike rentals during snowfall:  109.10574437962767
Standard deviation of bike rentals during no snowfall:  153.98643284765893
```

[9]:

```
print("Variance of bike rentals during snowfall: ", sigmaSnowfall)
print("Variance of bike rentals during no snowfall: ", sigmaNoSnowfall)
```

```
Variance of bike rentals during snowfall:  11904.063456632653
Variance of bike rentals during no snowfall:  23711.821501146576
```

[10]:

```
# Calculate Test Statistic T
T = (mean_snowfall - mean_noSnowfall) / np.sqrt(sigmaSnowfall/len(df_snowfall)␣
 ↪+ sigmaNoSnowfall/len(df_no_snowfall))
print("Test Statistic T: ", T)
```

```
Test Statistic T:  -12.599742371278047
```

[11]:

```
# Do Z test
from scipy.stats import norm

alpha = 0.05
z = norm.ppf(1-alpha/2)

print("Z value: ", z)
```

```
Z value:  1.959963984540054
```

[13]:

```
if(T >= -z):
    print("Null Hypothesis is accepted")
else:
    print("Failed to accept Null Hypothesis")
```

```
Failed to accept Null Hypothesis
```

[15]:
```
# Calculate p value
p = norm.cdf(T)
print("P value: ", p)
```

```
P value:  1.0591764873897083e-36
```

[ ]:
```

```

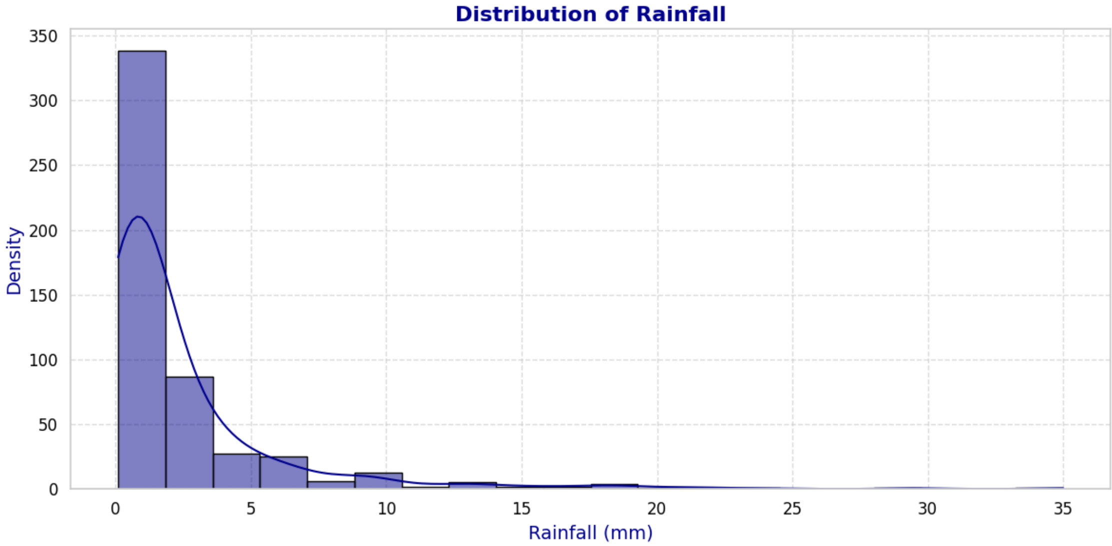
2 Question II

[16]:
```
# Read again the data
df = pd.read_csv("SeoulBikeData.csv")

# Remove the non functioning days
df = df[df['Functioning Day'] == 'Yes']

# Filter out the data with non zero rainfall
df = df[df['Rainfall(mm)'] != 0]

print("number of rows with non zero rainfall: ", df.shape[0])
```

```
number of rows with non zero rainfall:  516
```

[17]:
```
import matplotlib.pyplot as plt
import seaborn as sns

# Set the aesthetic style of the plots
sns.set(style="whitegrid")

# Plot
plt.figure(figsize=(12, 6))
sns.histplot(df['Rainfall(mm)'], bins=20, color='darkblue', edgecolor='black',␣
 ↪kde=True, linewidth=1)

# Title and labels
plt.title('Distribution of Rainfall', fontsize=16, fontweight='bold',␣
 ↪color='darkblue')
plt.xlabel('Rainfall (mm)', fontsize=14, color='darkblue')
plt.ylabel('Density', fontsize=14, color='darkblue')

# Customize tick parameters
plt.xticks(fontsize=12, color='black')
plt.yticks(fontsize=12, color='black')

# Add gridlines
plt.grid(True, linestyle='--', alpha=0.7)
```

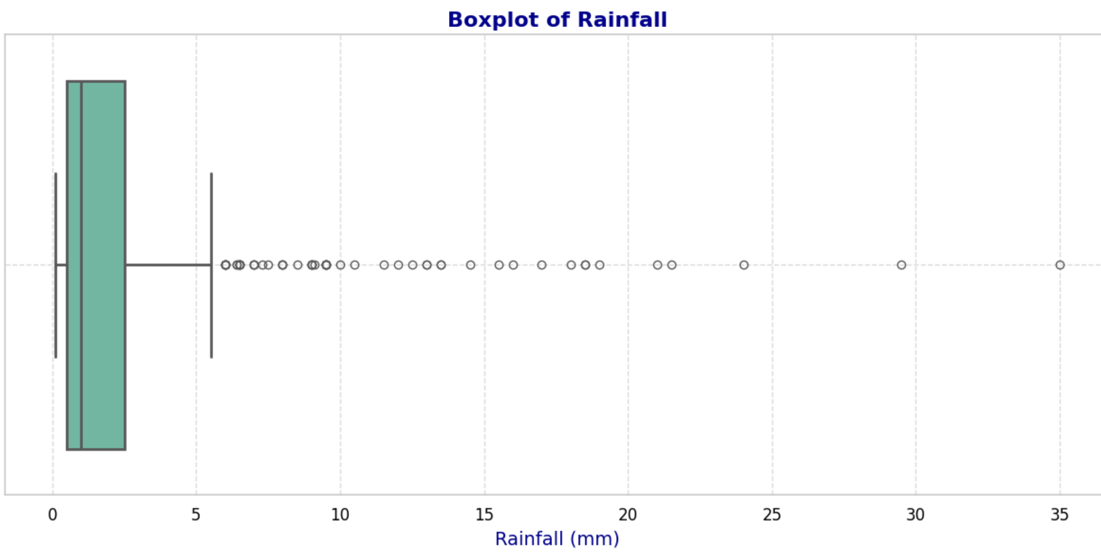
```
# Enhance the layout and show plot
plt.tight_layout()
plt.show()
```



[18]:
```
import matplotlib.pyplot as plt
import seaborn as sns

# Set the aesthetic style of the plots
sns.set(style="whitegrid")

# Plot
plt.figure(figsize=(12, 6))
sns.boxplot(x='Rainfall(mm)', data=df, palette='Set2', linewidth=2)

# Title and labels
plt.title('Boxplot of Rainfall', fontsize=16, fontweight='bold',␣
 ↪color='darkblue')
plt.xlabel('Rainfall (mm)', fontsize=14, color='darkblue')

# Customize tick parameters
plt.xticks(fontsize=12, color='black')
plt.yticks(fontsize=12, color='black')

# Add gridlines
plt.grid(True, linestyle='--', alpha=0.7)

# Enhance the layout and show plot
```

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

```
/tmp/ipykernel_368280/1555155085.py:9: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in
v0.14.0. Assign the `y` variable to `hue` and set `legend=False` for the same
effect.

  sns.boxplot(x='Rainfall(mm)', data=df, palette='Set2', linewidth=2)
```

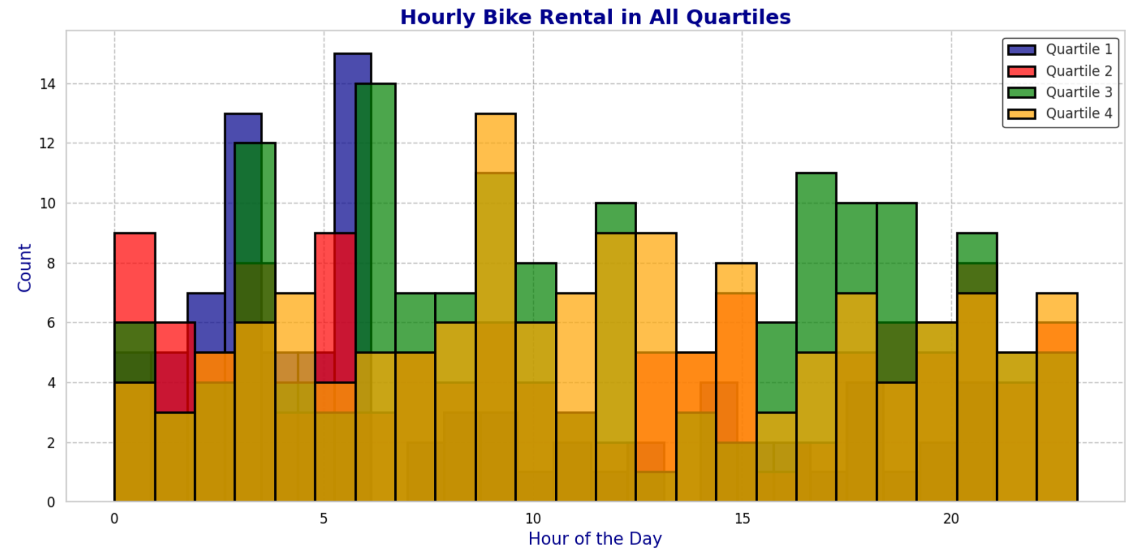


[19]:
```
# Separate based on Quartiles

dfQuartile1 = df[df['Rainfall(mm)'] < 0.5]
dfQuartile2 = df[(df['Rainfall(mm)'] >= 0.5) & (df['Rainfall(mm)'] < 1.00)]
dfQuartile3 = df[(df['Rainfall(mm)'] >= 1.00) & (df['Rainfall(mm)'] < 2.50)]
dfQuartile4 = df[df['Rainfall(mm)'] >= 2.50]
```

[20]:
```
print("Number of rows in Quartile 1: ", dfQuartile1.shape[0])
print("Number of rows in Quartile 2: ", dfQuartile2.shape[0])
print("Number of rows in Quartile 3: ", dfQuartile3.shape[0])
print("Number of rows in Quartile 4: ", dfQuartile4.shape[0])
```

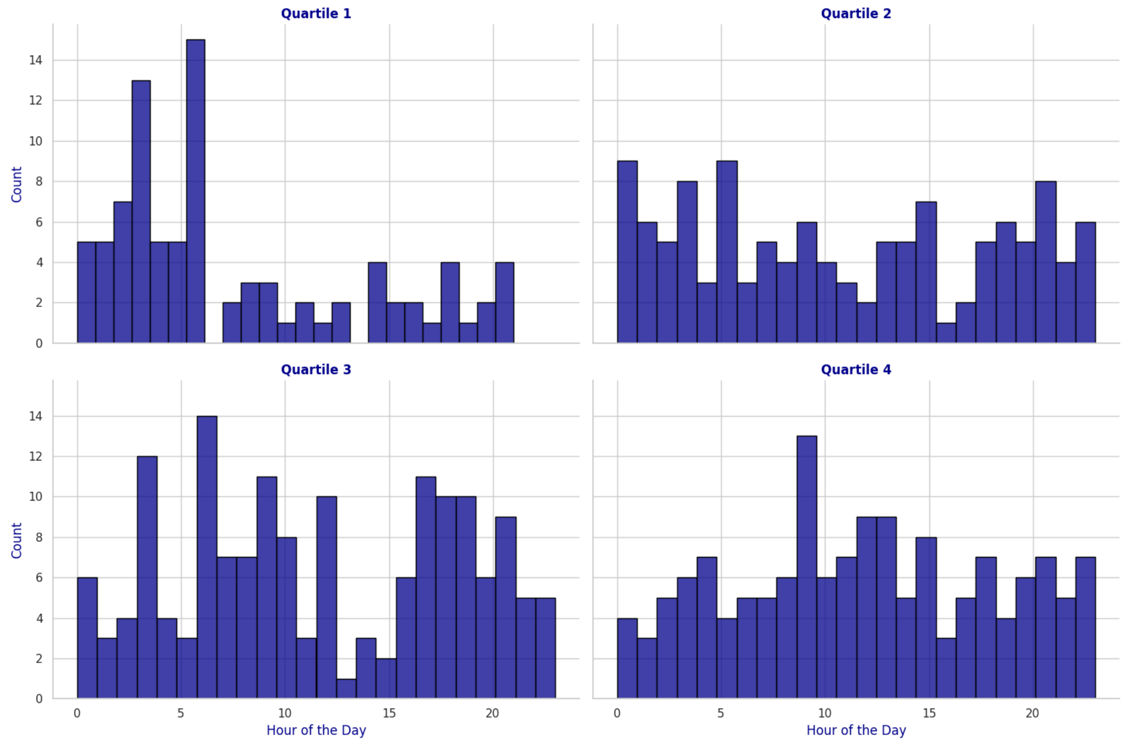
```
Number of rows in Quartile 1:  89
Number of rows in Quartile 2:  121
Number of rows in Quartile 3:  160
Number of rows in Quartile 4:  146
```

[21]:
```python
import matplotlib.pyplot as plt
import seaborn as sns

# Set the aesthetic style of the plots
sns.set(style="whitegrid")

# Plot
plt.figure(figsize=(14, 7))

# Quartile 1
sns.histplot(dfQuartile1['Hour'], bins=24, color='darkblue', edgecolor='black',␣
↪kde=False, linewidth=2, label='Quartile 1', alpha=0.7)

# Quartile 2
sns.histplot(dfQuartile2['Hour'], bins=24, color='red', edgecolor='black',␣
↪kde=False, linewidth=2, label='Quartile 2', alpha=0.7)

# Quartile 3
sns.histplot(dfQuartile3['Hour'], bins=24, color='green', edgecolor='black',␣
↪kde=False, linewidth=2, label='Quartile 3', alpha=0.7)

# Quartile 4
sns.histplot(dfQuartile4['Hour'], bins=24, color='orange', edgecolor='black',␣
↪kde=False, linewidth=2, label='Quartile 4', alpha=0.7)

# Title and labels
plt.title('Hourly Bike Rental in All Quartiles', fontsize=18,␣
↪fontweight='bold', color='darkblue')
plt.xlabel('Hour of the Day', fontsize=15, color='darkblue')
plt.ylabel('Count', fontsize=15, color='darkblue')

# Customize tick parameters
plt.xticks(fontsize=12, color='black')
plt.yticks(fontsize=12, color='black')

# Add gridlines
plt.grid(True, linestyle='--', color='gray', alpha=0.5)

# Add legend
plt.legend(fontsize=12, loc='upper right', frameon=True, facecolor='white',␣
↪edgecolor='black')

# Enhance the layout and show plot
plt.tight_layout()
plt.show()
```



[22]:
```
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd

# Combine quartiles into a single DataFrame for facet plotting
df_combined = pd.concat([
    dfQuartile1.assign(Quartile='Quartile 1'),
    dfQuartile2.assign(Quartile='Quartile 2'),
    dfQuartile3.assign(Quartile='Quartile 3'),
    dfQuartile4.assign(Quartile='Quartile 4')
])

# Plot
plt.figure(figsize=(14, 7))
g = sns.FacetGrid(df_combined, col='Quartile', col_wrap=2, height=5, aspect=1.5)
g.map(sns.histplot, 'Hour', bins=24, color='darkblue', edgecolor='black',␣
 ↪kde=False)

# Titles and labels
g.set_titles(col_template="{col_name}", fontsize=14, fontweight='bold',␣
 ↪color='darkblue')
g.set_axis_labels('Hour of the Day', 'Count', fontsize=12, color='darkblue')

# Adjust layout and show plot
plt.tight_layout()
plt.show()
```

```
<Figure size 1400x700 with 0 Axes>
```



Note: I have used chatGPT to make these plots more beautiful

[23]:
```
mean1 = dfQuartile1['Rented Bike Count'].mean()
mean2 = dfQuartile2['Rented Bike Count'].mean()
mean3 = dfQuartile3['Rented Bike Count'].mean()
mean4 = dfQuartile4['Rented Bike Count'].mean()

print("Mean of Rented Bike Count in Quartile 1: ", mean1)
print("Mean of Rented Bike Count in Quartile 2: ", mean2)
print("Mean of Rented Bike Count in Quartile 3: ", mean3)
print("Mean of Rented Bike Count in Quartile 4: ", mean4)
```

```
Mean of Rented Bike Count in Quartile 1:  252.0561797752809
Mean of Rented Bike Count in Quartile 2:  252.27272727272728
Mean of Rented Bike Count in Quartile 3:  127.1875
Mean of Rented Bike Count in Quartile 4:  89.02054794520548
```

[24]:
```
SSW = 0
SSW += sum((dfQuartile1['Rented Bike Count'] - mean1) ** 2)
SSW += sum((dfQuartile2['Rented Bike Count'] - mean2) ** 2)
SSW += sum((dfQuartile3['Rented Bike Count'] - mean3) ** 2)
SSW += sum((dfQuartile4['Rented Bike Count'] - mean4) ** 2)

print("SSW: ", SSW)
```

SSW: 33201816.03245729

[25]:
```
SSB = 0

SSB += len(dfQuartile1) * (mean1 - df['Rented Bike Count'].mean()) ** 2
SSB += len(dfQuartile2) * (mean2 - df['Rented Bike Count'].mean()) ** 2
SSB += len(dfQuartile3) * (mean3 - df['Rented Bike Count'].mean()) ** 2
SSB += len(dfQuartile4) * (mean4 - df['Rented Bike Count'].mean()) ** 2

print("SSB: ", SSB)
```

SSB: 2665086.6865349603

[26]:
```
F = (SSB / 3) / (SSW / (len(dfQuartile1) + len(dfQuartile2) + len(dfQuartile3)␣
 ↪+ len(dfQuartile4) - 4))

print("F: ", F)
```

F: 13.6992946627977

[27]:
```
# Import the f-distribution
from scipy.stats import f

# Define the number of groups and the degrees of freedom
num_groups = 4
dfn = num_groups - 1
dfd = len(dfQuartile1) + len(dfQuartile2) + len(dfQuartile3) + len(dfQuartile4)␣
 ↪- num_groups

# Calculate the critical value
critical_value = f.ppf(0.95, dfn, dfd)

print("Critical Value: ", critical_value)
```

Critical Value: 2.6223153068438396

[28]:
```
# Compare the F-value with the critical value
if F > critical_value:
    print("Reject the null hypothesis: There is a significant difference␣
 ↪between the group means.")
else:
    print("Fail to reject the null hypothesis: There is no significant␣
 ↪difference between the group means.")
```

Reject the null hypothesis: There is a significant difference between the group means.

[29]:
```python
# Calculate the p-value
p_value = 1 - f.cdf(F, dfn, dfd)

print("P-Value: ", p_value)
```

```
P-Value:  1.3142755661554872e-08
```

[30]:
```python
# Verify the results using the ANOVA test
from scipy.stats import f_oneway

# Perform the ANOVA test
f_statistic, p_value = f_oneway(dfQuartile1['Rented Bike Count'],␣
 ↪dfQuartile2['Rented Bike Count'], dfQuartile3['Rented Bike Count'],␣
 ↪dfQuartile4['Rented Bike Count'])

print("F-Statistic: ", f_statistic)
print("P-Value: ", p_value)
```

```
F-Statistic:  13.699294662797698
P-Value:  1.3142755691851183e-08
```

[ ]:
```python

```

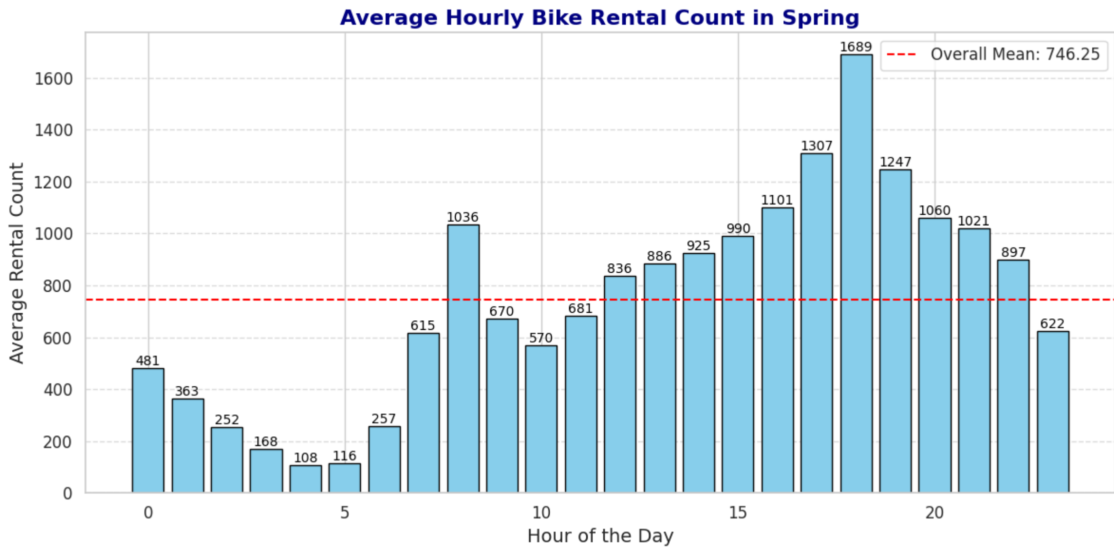
3 Question III

[31]:
```python
# Read the data
df = pd.read_csv("SeoulBikeData.csv")

# Remove the non functioning days
df = df[df['Functioning Day'] == 'Yes']

# Separate Spring and Winter data
df_spring = df[df['Seasons'] == 'Spring']
df_summer = df[df['Seasons'] == 'Summer']

print("Number of rows in Spring data: ", df_spring.shape[0])
print("Number of rows in Winter data: ", df_summer.shape[0])
```

```
Number of rows in Spring data:  2160
Number of rows in Winter data:  2208
```

[32]:
```python
import matplotlib.pyplot as plt

# Group by 'Hour' and calculate the mean 'Rented Bike Count' for spring
avg_hourly_rentals_spring = df_spring.groupby('Hour')['Rented Bike Count'].
 ↪mean()
```

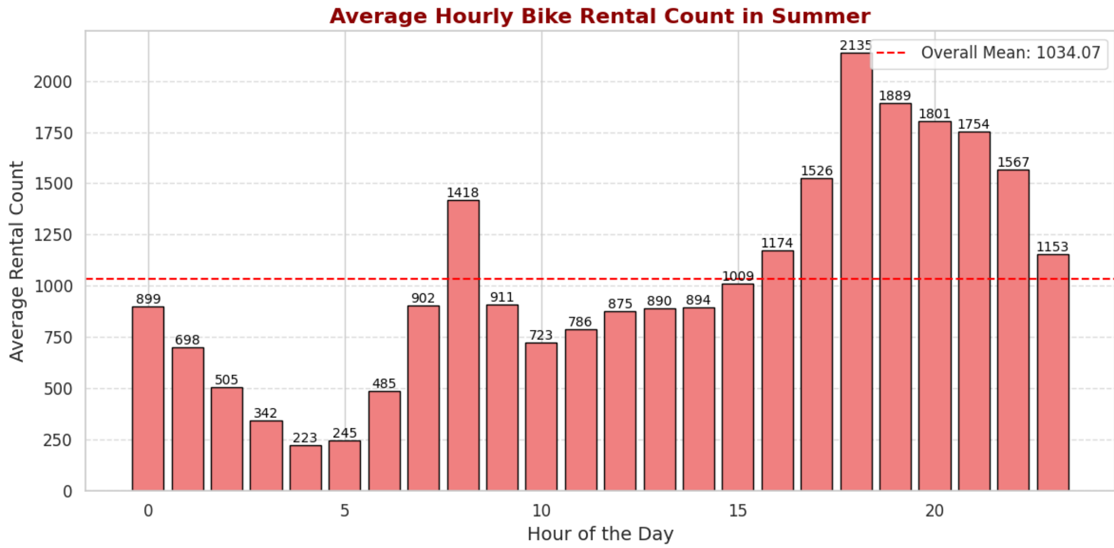
```python
# Plot
plt.figure(figsize=(12, 6))
bars = plt.bar(avg_hourly_rentals_spring.index, avg_hourly_rentals_spring,␣
↪color='skyblue', edgecolor='black')

# Add value labels on top of the bars
for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, int(yval), va='bottom',␣
↪ha='center', fontsize=10, color='black')

# Title and labels
plt.title('Average Hourly Bike Rental Count in Spring', fontsize=16,␣
↪fontweight='bold', color='navy')
plt.xlabel('Hour of the Day', fontsize=14)
plt.ylabel('Average Rental Count', fontsize=14)

# Customize tick parameters
plt.xticks(fontsize=12)
plt.yticks(fontsize=12)

# Add gridlines for the y-axis
plt.grid(axis='y', linestyle='--', alpha=0.7)

# Add a horizontal line for the mean
mean_value = avg_hourly_rentals_spring.mean()
plt.axhline(mean_value, color='red', linestyle='--', linewidth=1.5,␣
↪label=f'Overall Mean: {mean_value:.2f}')
plt.legend(fontsize=12, loc='upper right')

# Enhance the layout and show plot
plt.tight_layout()
plt.show()
```



[33]:

```
import matplotlib.pyplot as plt

# Group by 'Hour' and calculate the mean 'Rented Bike Count' for summer
avg_hourly_rentals_summer = df_summer.groupby('Hour')['Rented Bike Count'].
    ↪mean()

# Plot
plt.figure(figsize=(12, 6))
bars = plt.bar(avg_hourly_rentals_summer.index, avg_hourly_rentals_summer,␣
    ↪color='lightcoral', edgecolor='black')

# Add value labels on top of the bars
for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, int(yval), va='bottom',␣
    ↪ha='center', fontsize=10, color='black')

# Title and labels
plt.title('Average Hourly Bike Rental Count in Summer', fontsize=16,␣
    ↪fontweight='bold', color='darkred')
plt.xlabel('Hour of the Day', fontsize=14)
plt.ylabel('Average Rental Count', fontsize=14)

# Customize tick parameters
plt.xticks(fontsize=12)
plt.yticks(fontsize=12)

# Add gridlines for the y-axis
```

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

# Add a horizontal line for the mean
mean_value = avg_hourly_rentals_summer.mean()
plt.axhline(mean_value, color='red', linestyle='--', linewidth=1.5,␣
 ↪label=f'Overall Mean: {mean_value:.2f}')
plt.legend(fontsize=12, loc='upper right')

# Enhance the layout and show plot
plt.tight_layout()
plt.show()
```



[34]:
```
# Make a dataframe with 2 columns: Spring and summer and rows as average hourly␣
 ↪bike rental count
df_spring_avg = df_spring.groupby('Hour')['Rented Bike Count'].mean()
df_summer_avg = df_summer.groupby('Hour')['Rented Bike Count'].mean()
```

[35]:
```
# Merge the two dataframes
df_merged = pd.merge(df_spring_avg, df_summer_avg, on='Hour')
df_merged.columns = ['Spring', 'Summer']
```

[36]:
```
# Add Row sum and Column sum
df_merged.loc['Column Sum'] = df_merged.sum()
df_merged['Row Sum'] = df_merged.sum(axis=1)
```

[37]:
```
# Calculate the Expected Values for the Summer Season using formula (Row Total␣
 ↪* Column Total) / Grand Total
df_merged["Expected Spring"] = 3
```

```
df_merged["Expected Summer"] = 3
```

[42]:

```
try:
    colSum1 = df_merged.loc['Column Sum'].iloc[0]
    print(f'colSum1: {colSum1}')

    colSum2 = df_merged.loc['Column Sum'].iloc[1]
    print(f'colSum2: {colSum2}')

    total = df_merged.loc['Column Sum'].iloc[2]
    print(f'total: {total}')
except KeyError as e:
    print(f'KeyError: {e} - Check if the index exists in the DataFrame')
except IndexError as e:
    print(f'IndexError: {e} - Check if the position indices are correct')
```

```
colSum1: 17910.1
colSum2: 24817.760869565216
total: 42727.860869565215
```

[39]:

```
```

```
17910.1
24817.760869565216
42727.860869565215
```

```
/tmp/ipykernel_368280/4156945129.py:1: FutureWarning: Series.__getitem__
treating keys as positions is deprecated. In a future version, integer keys will
always be treated as labels (consistent with DataFrame behavior). To access a
value by position, use `ser.iloc[pos]`
  colSum1 = df_merged.loc['Column Sum'][0]
/tmp/ipykernel_368280/4156945129.py:4: FutureWarning: Series.__getitem__
treating keys as positions is deprecated. In a future version, integer keys will
always be treated as labels (consistent with DataFrame behavior). To access a
value by position, use `ser.iloc[pos]`
  colSum2 = df_merged.loc['Column Sum'][1]
/tmp/ipykernel_368280/4156945129.py:7: FutureWarning: Series.__getitem__
treating keys as positions is deprecated. In a future version, integer keys will
always be treated as labels (consistent with DataFrame behavior). To access a
value by position, use `ser.iloc[pos]`
  total = df_merged.loc['Column Sum'][2]
```

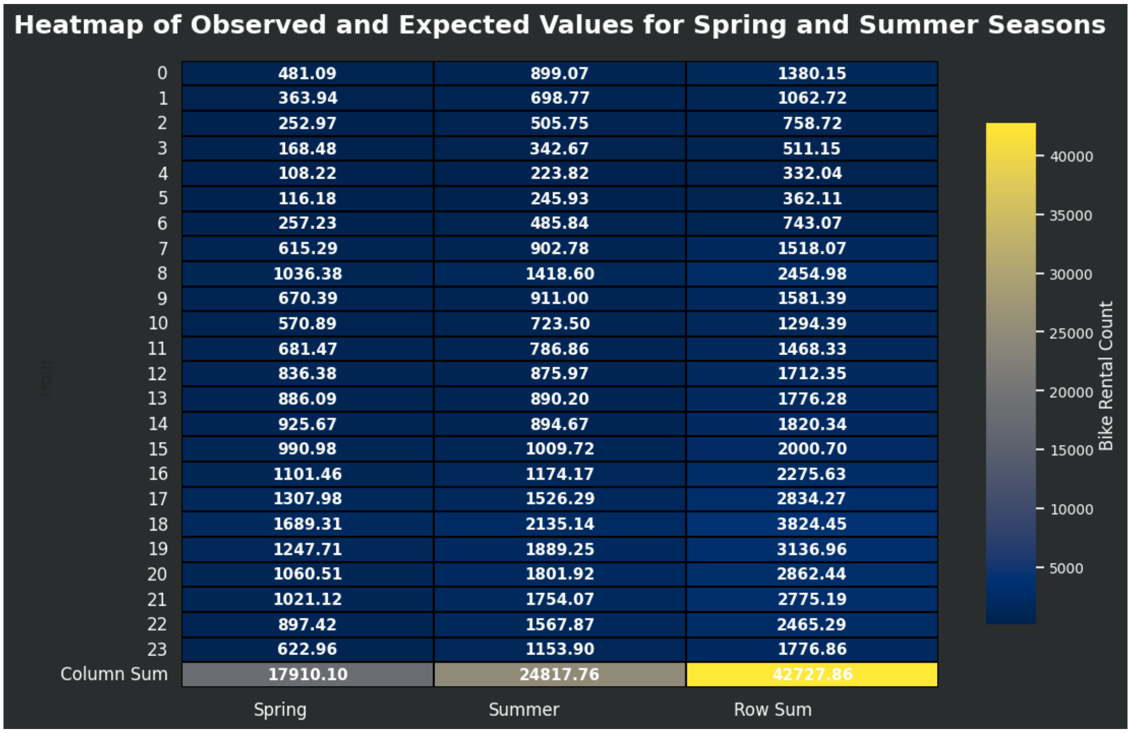
[45]:

```
# Ensure 'Expected Spring' and 'Expected Summer' columns exist
df_merged['Expected Spring'] = 0.0
df_merged['Expected Summer'] = 0.0

# Calculate expected values
for i in range(24):
```

```
    expectedValue1 = df_merged.iloc[i]['Row Sum'] * colSum1 / total
    expectedValue2 = df_merged.iloc[i]['Row Sum'] * colSum2 / total

    # Use .at[] for scalar assignments to avoid warnings
    df_merged.at[i, 'Expected Spring'] = expectedValue1
    df_merged.at[i, 'Expected Summer'] = expectedValue2
```

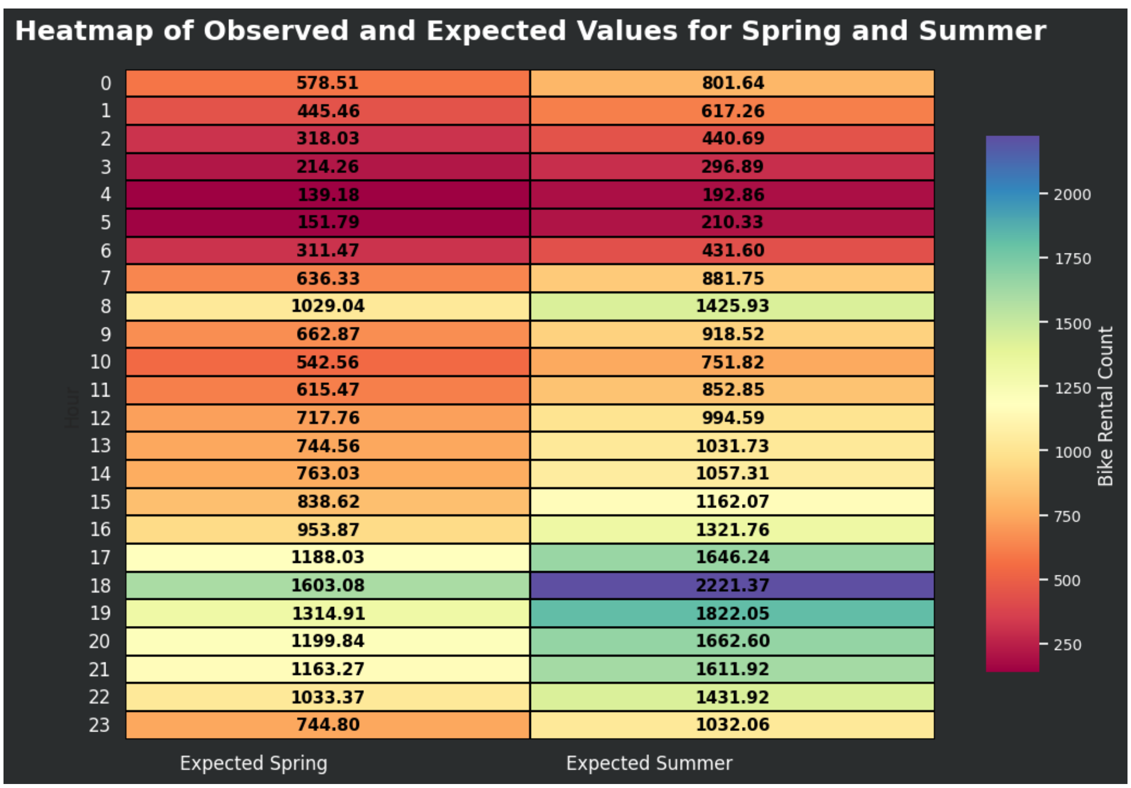
[46]:
```
import seaborn as sns
import matplotlib.pyplot as plt

# Set the aesthetic style of the plots to a dark background
sns.set(style="darkgrid")

# Increase the figure size
plt.figure(figsize=(12, 8))

# Plot the heatmap with a different color palette and enhanced styling
heatmap = sns.heatmap(
    df_merged.iloc[:, :3],
    annot=True,
    fmt=".2f",
    cmap='cividis',  # Changed to a vibrant color palette
    linewidths=0.3,  # Subtle grid lines
    linecolor='black',  # Grid line color
    cbar_kws={'shrink': 0.8, 'aspect': 10},  # Customized color bar
    annot_kws={"size": 11, "weight": "bold", "color": "white"},  # Annotation␣
 ↪text style
)

# Add a title with custom styling
plt.title('Heatmap of Observed and Expected Values for Spring and Summer␣
 ↪Seasons',
          fontsize=18, weight='bold', color='white', pad=20)

# Rotate the x and y labels for better readability
plt.xticks(ha='right', fontsize=12, color='white')
plt.yticks(rotation=0, fontsize=12, color='white')

# Customize axes and background
heatmap.figure.set_facecolor('#2a2d2e')  # Set background color
heatmap.set_facecolor('#2a2d2e')  # Set the face color of the plot

# Add a color bar with a label
colorbar = heatmap.collections[0].colorbar
colorbar.set_label('Bike Rental Count', fontsize=12, color='white')
colorbar.ax.tick_params(labelsize=10, colors='white')
```

```python
# Show the plot
plt.show()
```




```python
[47]: import seaborn as sns
import matplotlib.pyplot as plt

# Set the aesthetic style of the plots
sns.set(style="darkgrid")

# Increase the figure size
plt.figure(figsize=(12, 8))

# Plot the heatmap for the next two columns with enhanced aesthetics
heatmap = sns.heatmap(
    df_merged.iloc[:-1, 3:5],  # Select the next two columns
    annot=True,
    fmt=".2f",
    cmap='Spectral',  # Use a vibrant color palette
    linewidths=0.3,  # Add subtle grid lines
    linecolor='black',  # Grid line color
    cbar_kws={'shrink': 0.8, 'aspect': 10},  # Customize color bar
    annot_kws={"size": 11, "weight": "bold", "color": "black"},  # Annotation text style
)
```

```
# Add a title with custom styling
plt.title('Heatmap of Observed and Expected Values for Spring and Summer',
          fontsize=18, weight='bold', color='white', pad=20)

# Rotate the x and y labels for better readability
plt.xticks(ha='right', fontsize=12, color='white')
plt.yticks(rotation=0, fontsize=12, color='white')

# Customize axes and background
heatmap.figure.set_facecolor('#2a2d2e')  # Set background color
heatmap.set_facecolor('#2a2d2e')  # Set the face color of the plot

# Add a color bar with a label
colorbar = heatmap.collections[0].colorbar
colorbar.set_label('Bike Rental Count', fontsize=12, color='white')
colorbar.ax.tick_params(labelsize=10, colors='white')

# Show the plot
plt.show()
```



[48]:
```
# Compute the Test Statistic for Chi-Square Test where Observed is the summer␣
↪column except for the last row and Expected is the Expected Summer column
T = 0
for i in range(0, 24):
    E = df_merged.iloc[i]["Expected Summer"]
    O = df_merged.iloc[i]["Summer"]

    T += ((O - E) ** 2) / E

    E = df_merged.iloc[i]["Expected Spring"]
    O = df_merged.iloc[i]["Spring"]

    T += ((O - E) ** 2) / E

T
```

[48]: 536.676606781657

[49]:
```
DOF = 24
alpha = 0.05

from scipy.stats import chi2

critical_value = chi2.ppf(1 - alpha, DOF)
critical_value
```

[49]: 36.41502850180731

[50]:
```
# Compare the Test Statistic with the Critical Value
if T > critical_value:
    print("Reject the Null Hypothesis")
else:
    print("Fail to Reject the Null Hypothesis")
```

```
Reject the Null Hypothesis
```

[51]:
```
import scipy.stats as stats

# Assuming T is your Chi-Square test statistic and DOF is the degrees of freedom
p_value = stats.chi2.sf(T, DOF)
print(f"p-value: {p_value}")
```

```
p-value: 3.932021483326344e-98
```

[54]:
```
# Use library function to perform the Chi-Square Test
from scipy.stats import chi2_contingency
```

```
spring_data = df_merged.iloc[:, 0].values
summer_data = df_merged.iloc[:, 1].values

import numpy as np
import scipy.stats as stats
data = np.array([spring_data, summer_data])

chi2, p, dof, expected = stats.chi2_contingency(data)

print("Chi-Square Statistic: ", chi2)
print("P-Value: ", p)
print("Degrees of Freedom: ", dof)
```

```
Chi-Square Statistic:  536.676606781657
P-Value:  3.932021483326344e-98
Degrees of Freedom:  24
```

[55]:
```
print("Chi-Square Statistic: ", chi2)
print("P-Value: ", p)
print("Degrees of Freedom: ", dof)
print("Expected: ", expected)
```

```
Chi-Square Statistic:  536.676606781657
P-Value:  3.932021483326344e-98
Degrees of Freedom:  24
Expected:  [[  578.51475725   445.45532428   318.02882464   214.25781004
    139.17906551   151.78555715   311.4703832    636.32514653
   1029.04422707   662.86569378   542.56482696   615.47321903
    717.7582165    744.55947739   763.02630539   838.62495848
    953.86828444  1188.03236553  1603.08341705  1314.90989843
   1199.83768162  1163.26639225  1033.36842855   744.79973893
  17910.1       ]
 [  801.63934903   617.26085929   440.68784203   296.89388078
    192.8583741    210.32700324   431.59990666   881.74635105
   1425.9313768    918.52319511   751.82406193   852.85214329
    994.58695258  1031.72506368  1057.31427432  1162.0702106
   1321.76118416  1646.23889051  2221.36899841  1822.05121268
   1662.59734254  1611.92104737  1431.92335889  1032.05799054
  24817.76086957]]
```

[ ]: