Sheth L.U.J College of Arts & Sir M.V. College of Science and Commerce
Data Science
PRACTICAL NO. 5

Aim: ANOVA (Analysis of Variance)

a) Perform one-way ANOVA to compare means across multiple groups.
b) Conduct post-hoc tests to identify significant differences between group means.

CODE:

- ***Importing libraries***

```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from scipy import stats
import statsmodels.api as sm
from statsmodels.formula.api import ols
from statsmodels.stats.multicomp import pairwise_tukeyhsd
```

- ***Load Dataset***

```
df = pd.read_csv("tip.csv")
print(df.head())
```

- ***One-Way ANOVA***

```
days = df['day'].unique()
data = {day: df['total_bill'][df['day'] == day] for day in days}
F_stat, p_value = stats.f_oneway(data['Thur'], data['Fri'], data['Sat'], data['Sun'])
print("F-statistic:", F_stat)
print("p-value:", p_value)
if p_value < 0.05:
   print("Reject null hypothesis → Total bill differs significantly across days.")
else:
   print("Fail to reject null hypothesis → Total bill does not differ significantly across days.")

plt.figure(figsize=(8,5))
sns.boxplot(x='day', y='total_bill', data=df, palette='Set2')
plt.title("Total Bill Across Days")
plt.show()
```

- ***Two-Way ANOVA***

```
# Build the model
model = ols('total_bill ~ C(day) * C(smoker)', data=df).fit()
# ANOVA table
anova_table = sm.stats.anova_lm(model, typ=2)
print(anova_table)

# Interaction plot using seaborn
plt.figure(figsize=(8,5))
sns.pointplot(x='day', y='total_bill', hue='smoker', data=df, palette='Set1', dodge=True, markers=["o", "s"],
capsize=0.1)
plt.title("Interaction Plot: Total Bill by Day and Smoker Status")
plt.show()
```

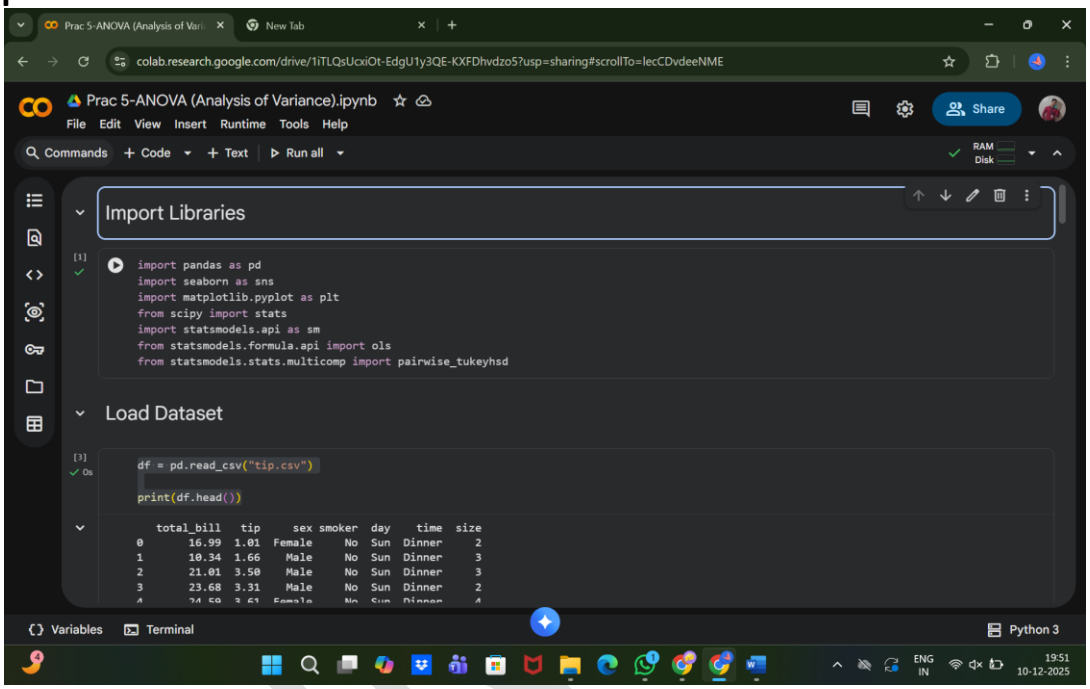
- ***Post-Hoc Test: Tukey HSD***

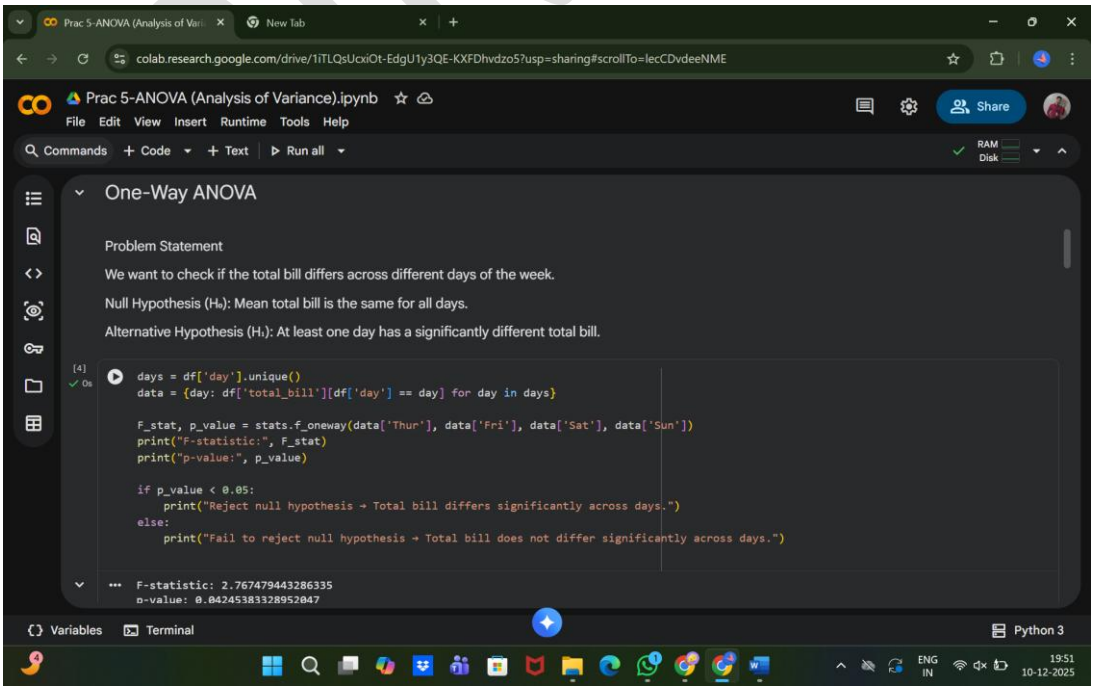
```
# Tukey HSD test for pairwise comparison
```

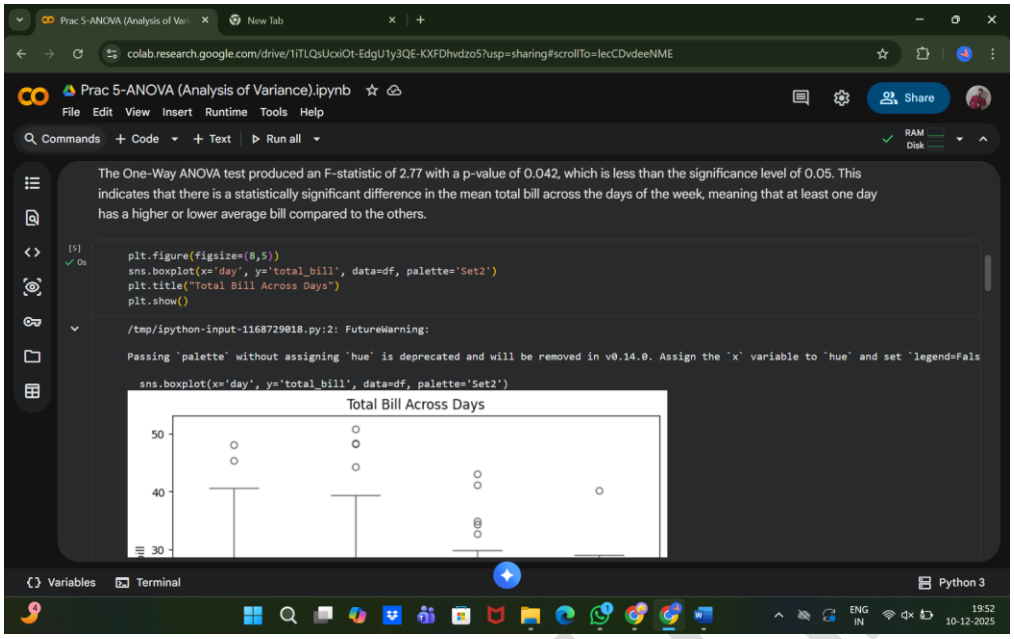
```
tukey = pairwise_tukeyhsd(endog=df['total_bill'],
                          groups=df['day'],
                          alpha=0.05)
print(tukey)

# Plotting Tukey results
tukey.plot_simultaneous(figsize=(8,5))
plt.title("Tukey HSD: Total Bill Comparison Across Days")
plt.show()
```

Output:






Prac 5-ANOVA (Analysis of Variance).ipynb
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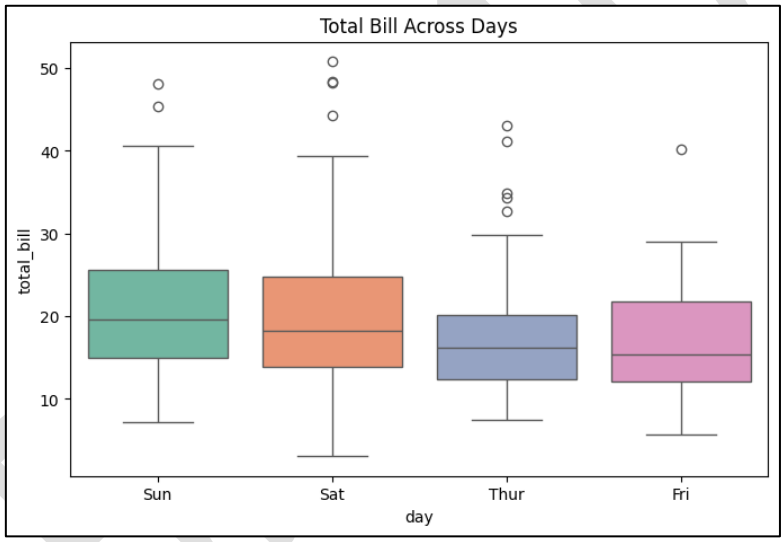
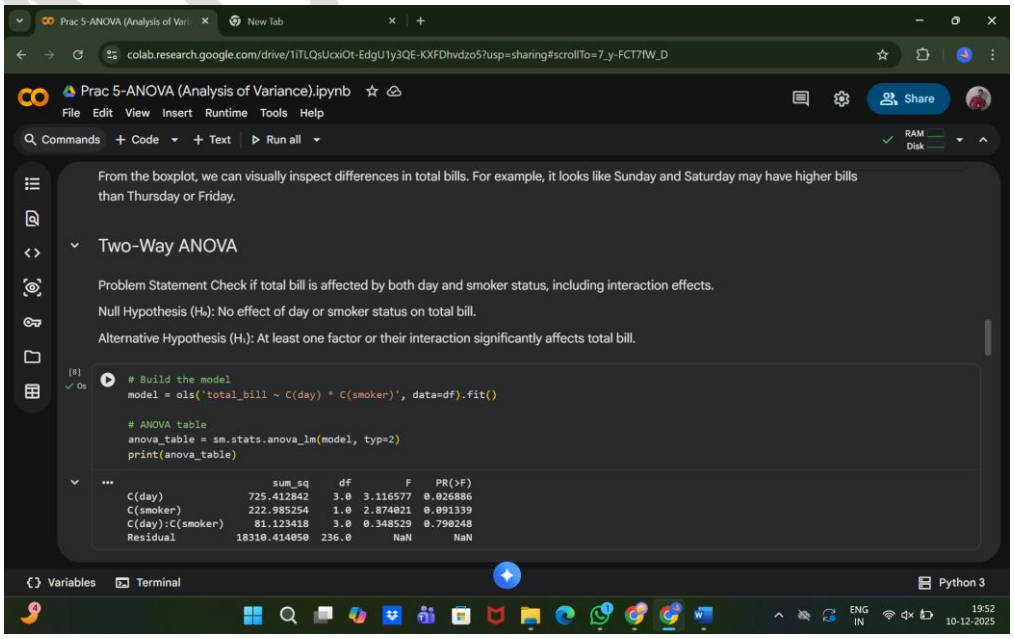
The One-Way ANOVA test produced an F-statistic of 2.77 with a p-value of 0.042, which is less than the significance level of 0.05. This indicates that there is a statistically significant difference in the mean total bill across the days of the week, meaning that at least one day has a higher or lower average bill compared to the others.
plt.figure(figsize=(8,5))
sns.boxplot(x='day', y='total_bill', data=df, palette='Set2')
plt.title("Total Bill Across Days")
plt.show()
/tmp/ipython-input-1168729018.py:2: FutureWarning:
Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=Fals
sns.boxplot(x='day', y='total_bill', data=df, palette='Set2')
Total Bill Across Days
50
40
30
Variables
Terminal
Python 3


Total Bill Across Days
total_bill
50
40
30
20
10
Sun
Sat
Thur
Fri
day


Prac 5-ANOVA (Analysis of Variance).ipynb
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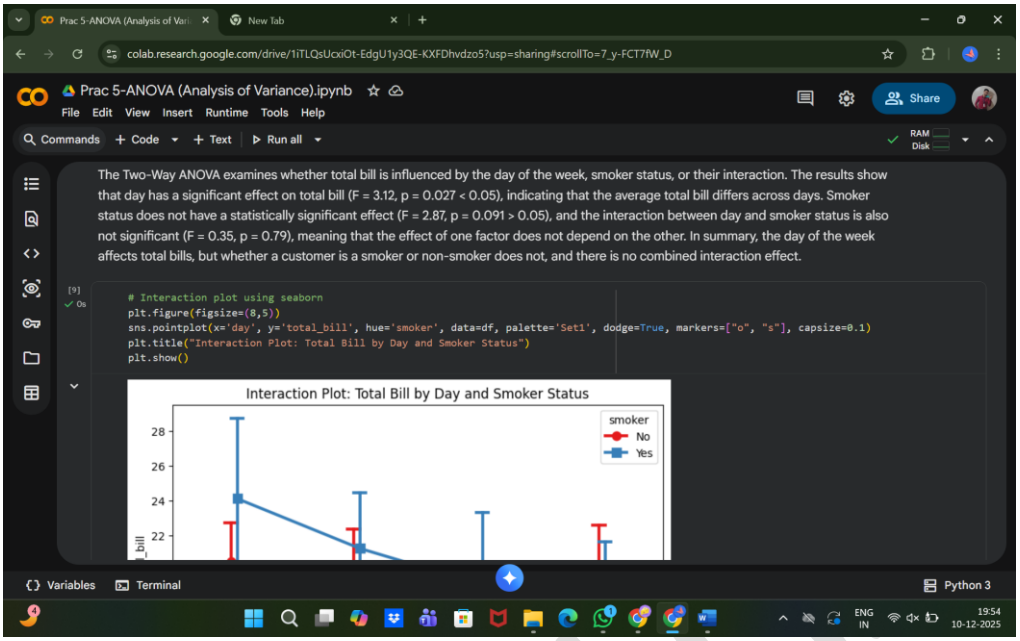
From the boxplot, we can visually inspect differences in total bills. For example, it looks like Sunday and Saturday may have higher bills than Thursday or Friday.
Two-Way ANOVA
Problem Statement Check if total bill is affected by both day and smoker status, including interaction effects.
Null Hypothesis (H₀): No effect of day or smoker status on total bill.
Alternative Hypothesis (H₁): At least one factor or their interaction significantly affects total bill.
# Build the model
model = ols('total_bill ~ C(day) * C(smoker)', data=df).fit()
# ANOVA table
anova_table = sm.stats.anova_lm(model, typ=2)
print(anova_table)
sum_sq df F PR(>F)
C(day) 725.412842 3.0 3.116577 0.026886
C(smoker) 222.985254 1.0 2.874021 0.091339
C(day):C(smoker) 81.123418 3.0 0.348529 0.790248
Residual 18310.414050 236.0 NaN NaN
Variables
Terminal
Python 3


Prac 5-ANOVA (Analysis of Variance).ipynb
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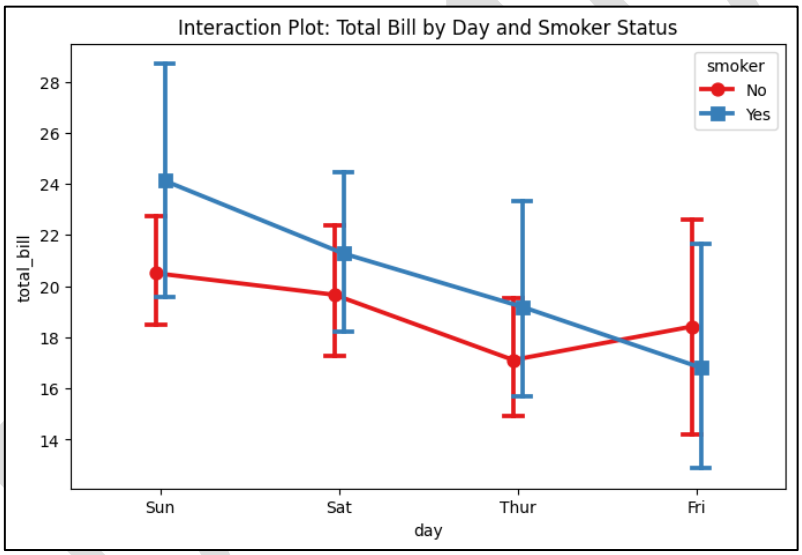
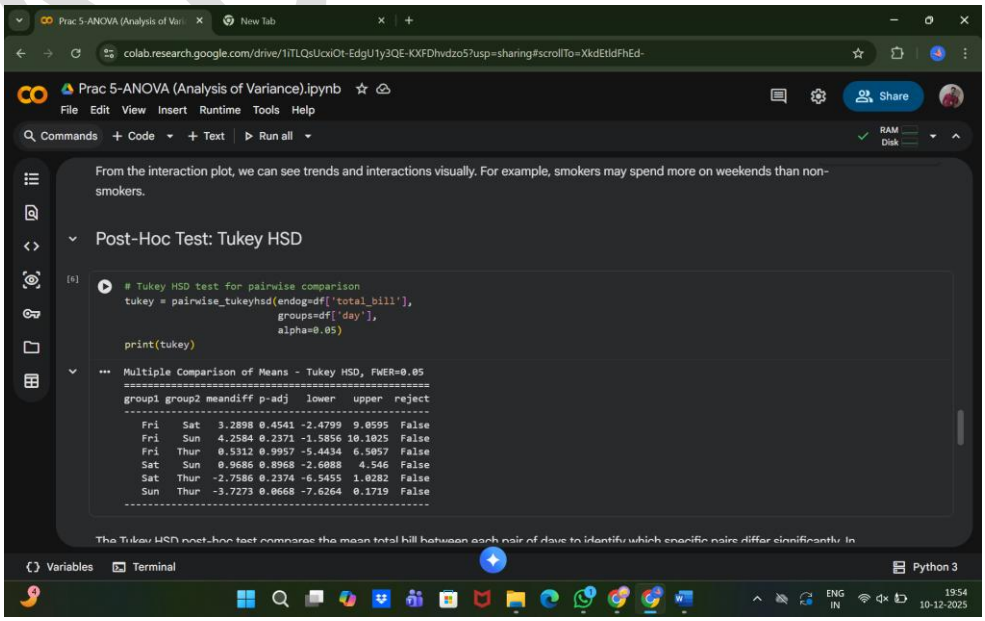
The Two-Way ANOVA examines whether total bill is influenced by the day of the week, smoker status, or their interaction. The results show that day has a significant effect on total bill (F = 3.12, p = 0.027 < 0.05), indicating that the average total bill differs across days. Smoker status does not have a statistically significant effect (F = 2.87, p = 0.091 > 0.05), and the interaction between day and smoker status is also not significant (F = 0.35, p = 0.79), meaning that the effect of one factor does not depend on the other. In summary, the day of the week affects total bills, but whether a customer is a smoker or non-smoker does not, and there is no combined interaction effect.
# Interaction plot using seaborn
plt.figure(figsize=(8,5))
sns.pointplot(x='day', y='total_bill', hue='smoker', data=df, palette='Set1', dodge=True, markers=["o", "s"], capsize=0.1)
plt.title("Interaction Plot: Total Bill by Day and Smoker Status")
plt.show()
Interaction Plot: Total Bill by Day and Smoker Status
smoker
No
Yes
Variables Terminal
Python 3


Interaction Plot: Total Bill by Day and Smoker Status
smoker
No
Yes
total_bill
day
Sun
Sat
Thur
Fri


Prac 5-ANOVA (Analysis of Variance).ipynb
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From the interaction plot, we can see trends and interactions visually. For example, smokers may spend more on weekends than non-smokers.
Post-Hoc Test: Tukey HSD
# Tukey HSD test for pairwise comparison
tukey = pairwise_tukeyhsd(endog=df['total_bill'],
groups=df['day'],
alpha=0.05)
print(tukey)
Multiple Comparison of Means - Tukey HSD, FWER=0.05
group1 group2 meandiff p-adj lower upper reject
Fri Sat 3.2898 0.4541 -2.4799 9.0595 False
Fri Sun 4.2584 0.2371 -1.5856 10.1025 False
Fri Thur 0.5312 0.9957 -5.4434 6.5057 False
Sat Sun 0.9686 0.8968 -2.6088 4.546 False
Sat Thur -2.7586 0.2374 -6.5455 1.0282 False
Sun Thur -3.7273 0.0668 -7.6264 0.1719 False
Variables Terminal
Python 3

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PRACTICAL NO. 5