Lab 2: Regression Analysis

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Simple Linear Regression

Importing Libraries

In [22]:
```
import pandas as pd # type: ignore
import matplotlib.pyplot as plt # type: ignore
from sklearn.model_selection import train_test_split # type: ignore
from sklearn.linear_model import LinearRegression # type: ignore
from sklearn.metrics import mean_squared_error, r2_score , mean_absolute_error,mean_absolute_percentage_error,r2_score # type:
```

Importing Data

In [23]:
```
df = pd.read_csv(r"Salary_Data.csv")
```

Exploratory Data Analysis

In [24]:
```
df.head()
```

Out[24]:

	Years of Experience	Salary
0	5.0	90000.0
1	3.0	65000.0
2	15.0	150000.0
3	7.0	60000.0
4	20.0	200000.0

In [25]:
```
df.describe()
```

Out[25]:

	Years of Experience	Salary
count	6701.000000	6699.000000
mean	8.094687	115326.964771
std	6.059003	52786.183911
min	0.000000	350.000000
25%	3.000000	70000.000000
50%	7.000000	115000.000000
75%	12.000000	160000.000000
max	34.000000	250000.000000

In [26]:
```
df.isnull().sum()
```

Out[26]:
```
Years of Experience    3
Salary                 5
dtype: int64
```

Dropping `Na` Values

In [27]:
```python
df = df.dropna()
```

Double Checking `Na` values

In [28]:
```python
df.isnull().sum()
```

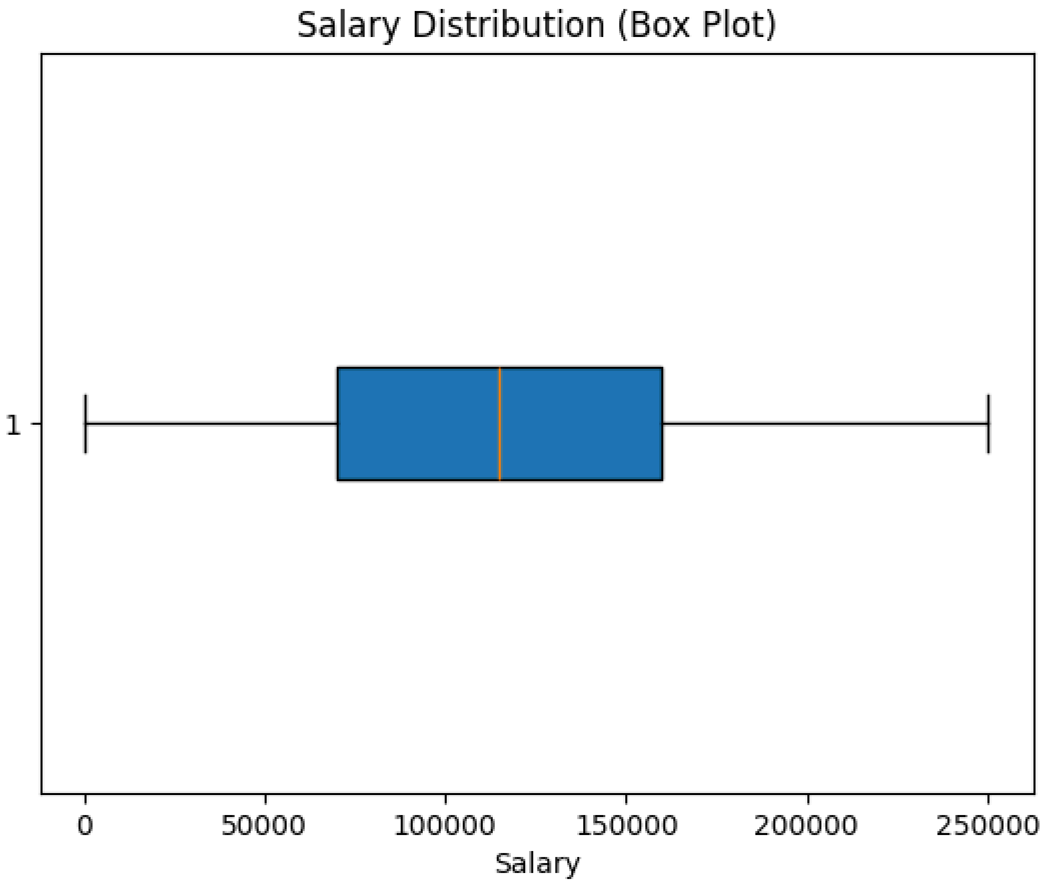
Out[28]:
```
Years of Experience    0
Salary                 0
dtype: int64
```

Scatter Plot

In [29]:
```python
import matplotlib.pyplot as plt #type: ignore
# Scatter plot
plt.scatter(df['Years of Experience'], df['Salary'], alpha=0.8)

# Adding labels and title
plt.title('Experience vs Salary')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.grid(True)

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

Boxplot

In [30]:
```
plt.boxplot(df['Salary'], vert=False, patch_artist=True)
plt.title('Salary Distribution (Box Plot)')
plt.xlabel('Salary')
plt.show()
```



Removing Outliers

In [31]:
```
from scipy.stats import zscore #type: ignore

# Compute Z-scores for each column
z_scores = df.apply(zscore)

# Remove rows where Z-scores are above the threshold
threshold = 3
filtered_df = df[(z_scores['Years of Experience'].abs() < threshold) &
                 (z_scores['Salary'].abs() < threshold)]
```

```
print("Filtered DataFrame using Z-score:")
filtered_df.head()
df = filtered_df
df.head()
```

```
Filtered DataFrame using Z-score:
```

Out[31]:

	Years of Experience	Salary
0	5.0	90000.0
1	3.0	65000.0
2	15.0	150000.0
3	7.0	60000.0
4	20.0	200000.0

Defining $Feature$ & $Target$ Variable

In [32]:

```
X = df[['Years of Experience']]  # Features (independent variable)
y = df['Salary']         # Target (dependent variable)

# Train-test split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

In [33]:

```
X_train.head()
```

Out[33]:

	Years of Experience
5236	1.0
3810	6.0
5788	11.0
2444	20.0
2822	4.0

Model Creation & Fitting

In [34]:
```
# Create and train the linear regression model
model = LinearRegression()
model.fit(X_train, y_train)

# Display model coefficients
print("Model Coefficients:", model.coef_)
print("Model Intercept:", model.intercept_)
```

```
Model Coefficients: [7628.64855815]
Model Intercept: 54782.12093941802
```

Making Predictions

In [35]:
```
y_pred = model.predict(X_test)
y_pred
```

Out[35]:
```
array([100554.01228834, 100554.01228834,  62410.76949757, ...,
        70039.41805572, 176840.49786987, 115811.30940465])
```

Model Evaluation

In [36]:
```
mae = mean_absolute_error(y_test, y_pred)
mape = mean_absolute_percentage_error(y_test, y_pred)
mse = mean_squared_error(y_test, y_pred)
r_squared = r2_score(y_test, y_pred)
print('Mean Absolute Error = ', mae)
print('Mean Absolute Percentage Error = ', mape)
print('Mean Squared Error = ', mse)
print('R2 Square = ', r_squared)
```

```
Mean Absolute Error =  23915.596408834117
Mean Absolute Percentage Error =  0.36376219576985663
Mean Squared Error =  887272056.0967814
R2 Square =  0.6824007270036381
```

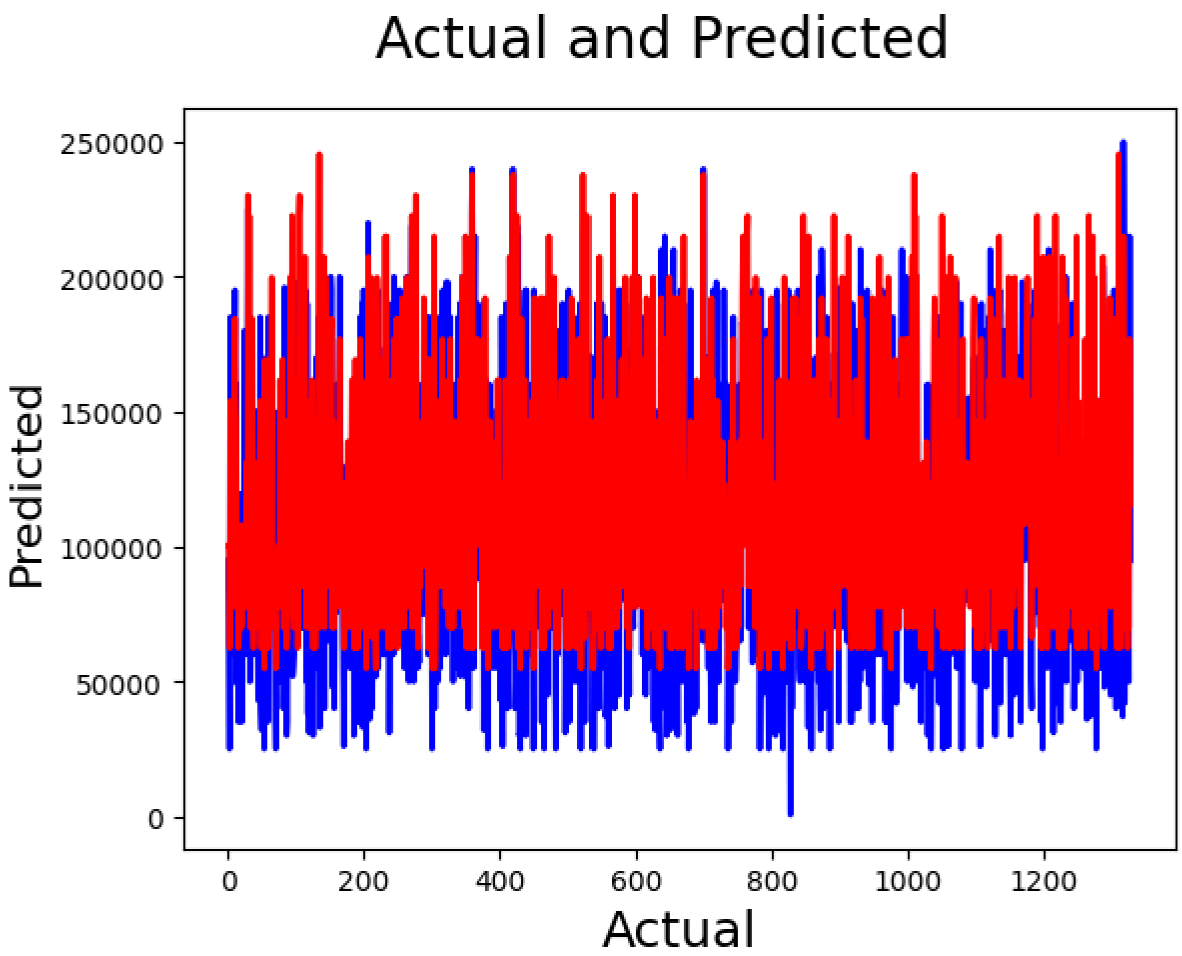
Plotting the Model

In [37]:
```
# Plot the data points
plt.scatter(X, y, color='blue', label='Data points')

# Plot the regression line
plt.plot(X, model.predict(X), color='red', label='Regression line')

plt.title('Experience vs Salary (Linear Regression)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.legend()
plt.show()
```

Actual vs Predicted graph

In [38]:
```
c = [i for i in range(1,len(y_test)+1,1)]
fig = plt.figure()
plt.plot(c,y_test, color="blue", linewidth=2, linestyle="-")
plt.plot(c,y_pred, color="red",  linewidth=2, linestyle="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Actual', fontsize=18)
plt.ylabel('Predicted', fontsize=16)
```

Out[38]:
```
Text(0, 0.5, 'Predicted')
```



Predicting our Data

In [39]:
```
model.predict([[10.0]])
```

```
c:\Users\abhij\AppData\Local\Programs\Python\Python313\Lib\site-packages\sklearn\utils\validation.py:2739: UserWarning: X does not have valid feature names, but LinearRegression was fitted with feature names
  warnings.warn(
```

Out[39]:
```
array([131068.60652095])
```

Multiple Linear Regression

Importing Libraries

In [40]:
```
import pandas as pd # type: ignore
import matplotlib.pyplot as plt # type: ignore
import seaborn as sns# type: ignore
from sklearn.model_selection import train_test_split # type: ignore
from sklearn.linear_model import LinearRegression # type: ignore
from sklearn.metrics import mean_absolute_error # type: ignore
from sklearn.metrics import mean_absolute_percentage_error # type: ignore
from sklearn.metrics import mean_squared_error # type: ignore
from sklearn.metrics import r2_score # type: ignore
```

Reading data

In [41]:
```
df = pd.read_csv(r"auto-mpg.csv")
```

Exploratory Data Analysis

In [42]:
```
df.head()
```

Out[42]:

	mpg	cylinders	displacement	horsepower	weight	acceleration	model year	origin	car name
0	18.0	8	307.0	130	3504	12.0	70	1	chevrolet chevelle malibu
1	15.0	8	350.0	165	3693	11.5	70	1	buick skylark 320
2	18.0	8	318.0	150	3436	11.0	70	1	plymouth satellite
3	16.0	8	304.0	150	3433	12.0	70	1	amc rebel sst
4	17.0	8	302.0	140	3449	10.5	70	1	ford torino

In [43]:
```
df.describe()
```

Out[43]:

	mpg	cylinders	displacement	weight	acceleration	model year	origin
count	398.000000	398.000000	398.000000	398.000000	398.000000	398.000000	398.000000
mean	23.514573	5.454774	193.425879	2970.424623	15.568090	76.010050	1.572864
std	7.815984	1.701004	104.269838	846.841774	2.757689	3.697627	0.802055
min	9.000000	3.000000	68.000000	1613.000000	8.000000	70.000000	1.000000
25%	17.500000	4.000000	104.250000	2223.750000	13.825000	73.000000	1.000000
50%	23.000000	4.000000	148.500000	2803.500000	15.500000	76.000000	1.000000
75%	29.000000	8.000000	262.000000	3608.000000	17.175000	79.000000	2.000000
max	46.600000	8.000000	455.000000	5140.000000	24.800000	82.000000	3.000000

Checking for `Na` values

In [44]:

```
df.isnull().sum()
```

Out[44]:

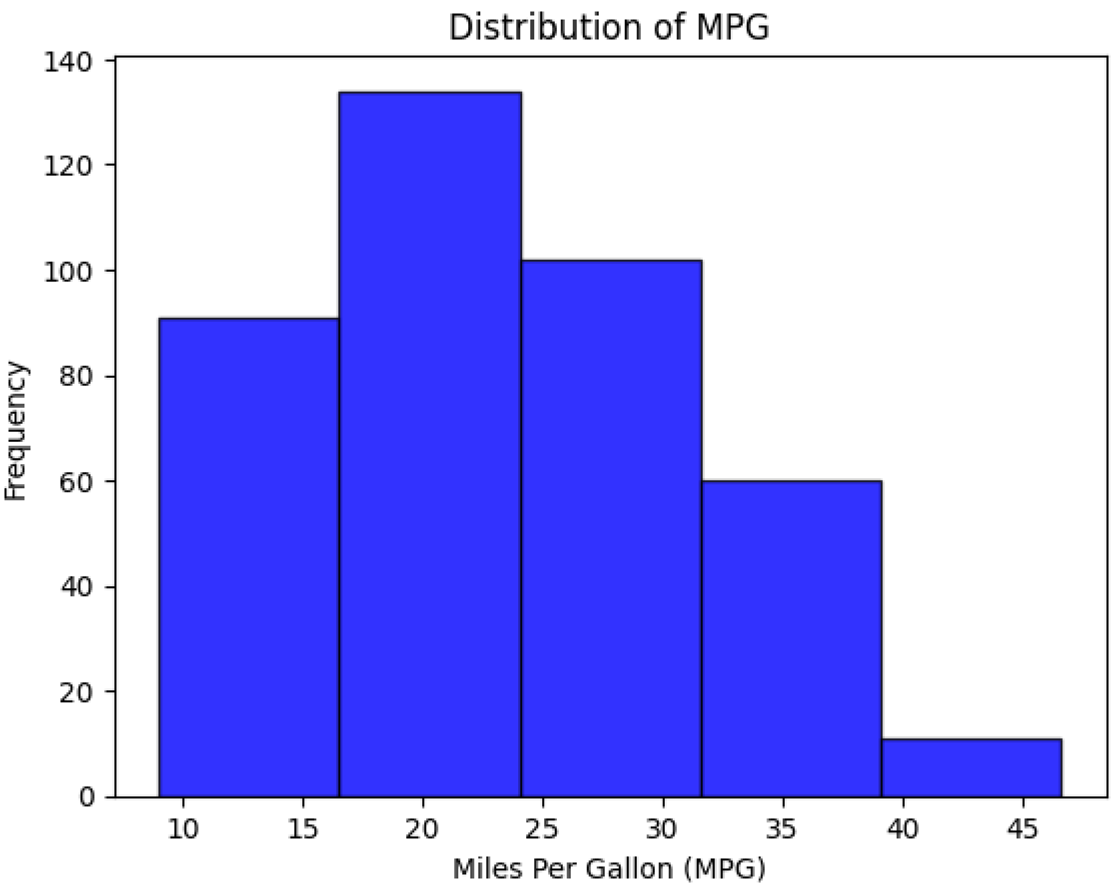
```
mpg             0
cylinders       0
displacement    0
horsepower      0
weight          0
acceleration    0
model year      0
origin          0
car name        0
dtype: int64
```

Histogram

In [45]:

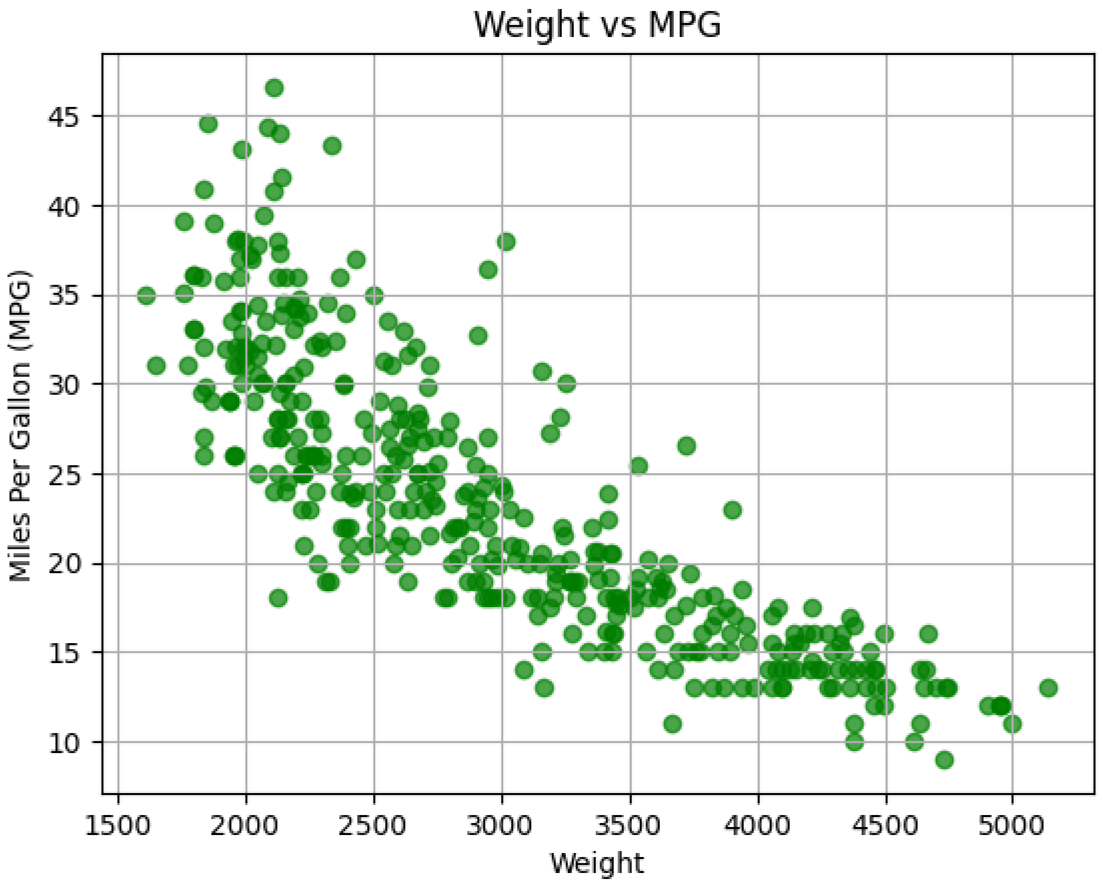
```
# Histogram
plt.hist(df['mpg'], bins=5, alpha=0.8, color='blue', edgecolor='black')
plt.title('Distribution of MPG')
plt.xlabel('Miles Per Gallon (MPG)')
```

```
plt.ylabel('Frequency')
plt.show()
```



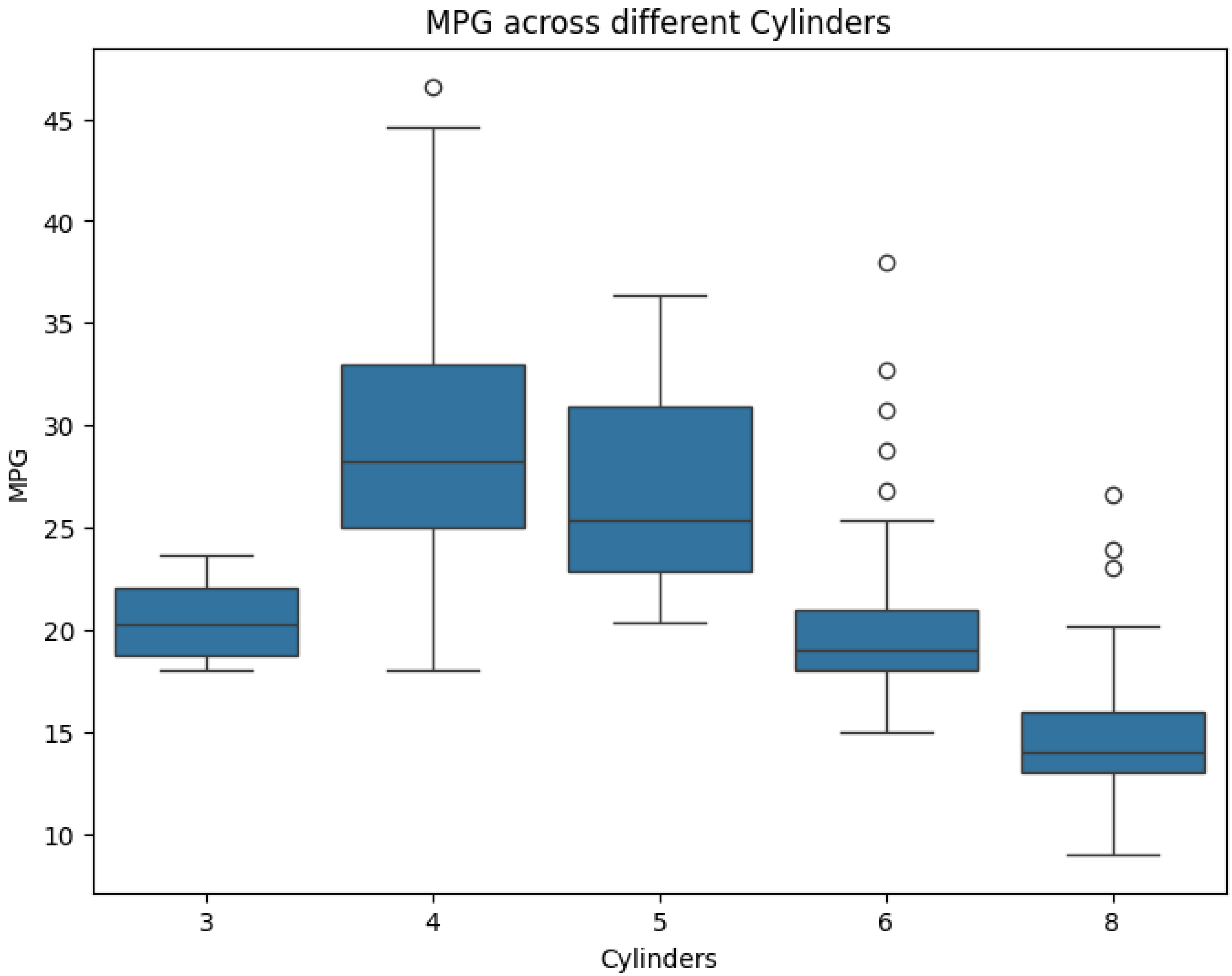
Scatter Plot

In [46]:
```
plt.scatter(df['weight'], df['mpg'], color='green', alpha=0.7)
plt.title('Weight vs MPG')
plt.xlabel('Weight')
plt.ylabel('Miles Per Gallon (MPG)')
plt.grid(True)
plt.show()
```



Boxplot

In [47]:
```
# Boxplot for 'mpg' across different 'cylinders'
plt.figure(figsize=(8, 6))
sns.boxplot(x='cylinders', y='mpg', data=df)
plt.title('MPG across different Cylinders')
plt.xlabel('Cylinders')
plt.ylabel('MPG')
plt.show()
```



Checking unique values

In [48]:
```
df.horsepower.unique()
```

Out[48]:
```
array(['130', '165', '150', '140', '198', '220', '215', '225', '190',
       '170', '160', '95', '97', '85', '88', '46', '87', '90', '113',
       '200', '210', '193', '?', '100', '105', '175', '153', '180', '110',
       '72', '86', '70', '76', '65', '69', '60', '80', '54', '208', '155',
       '112', '92', '145', '137', '158', '167', '94', '107', '230', '49',
       '75', '91', '122', '67', '83', '78', '52', '61', '93', '148',
       '129', '96', '71', '98', '115', '53', '81', '79', '120', '152',
       '102', '108', '68', '58', '149', '89', '63', '48', '66', '139',
       '103', '125', '133', '138', '135', '142', '77', '62', '132', '84',
       '64', '74', '116', '82'], dtype=object)
```

Handling the `?`

In [49]:
```
df['horsepower'] = pd.to_numeric(df['horsepower'], errors='coerce')
df['horsepower'] = df['horsepower'].fillna(df['horsepower'].mean())  # Filling with mean
df['horsepower'] = df['horsepower'].astype(int)
```

Defining *Features* & *Targets*

In [50]:
```
X = df[['horsepower', 'weight', 'cylinders']]  # Independent variables
y = df['mpg']  # Dependent variable
```

Train-Test split

In [51]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

Initialize and fit the model

In [52]:
```
model = LinearRegression()
model.fit(X_train, y_train)

# Display coefficients
print("Model Coefficients:", model.coef_)
print("Model Intercept:", model.intercept_)
```

```
Model Coefficients: [-0.04200823 -0.0055421  -0.38424958]
Model Intercept: 46.4888075862964
```

Making predictions on the test set

In [58]:
```python
y_pred = model.predict(X_test)
y_pred[:5]
```

Out[58]:
```
array([32.77730668, 27.08515113, 25.3846003 , 15.27770931, 13.63170611])
```

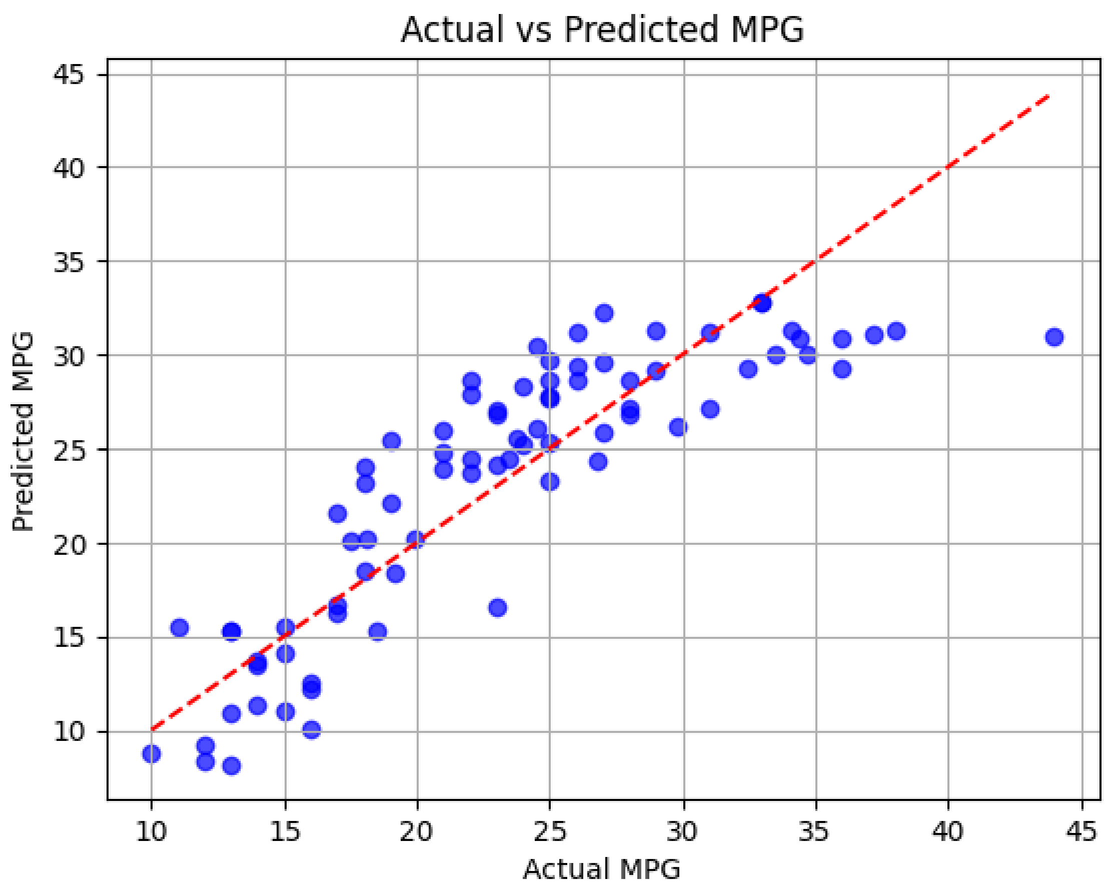
Evaluating the model

In [59]:
```python
mae = mean_absolute_error(y_test, y_pred)
mape = mean_absolute_percentage_error(y_test, y_pred)
mse = mean_squared_error(y_test, y_pred)
r_squared = r2_score(y_test, y_pred)
print('Mean Absolute Error = ', mae)
print('Mean Absolute Percentage Error = ', mape)
print('Mean Squared Error = ', mse)
print('R2 Square = ', r_squared)
```

```
Mean Absolute Error =  3.104054179560218
Mean Absolute Percentage Error =  0.14277970747073176
Mean Squared Error =  14.498733635097096
R2 Square =  0.7303386159867213
```

Checking Regression Line

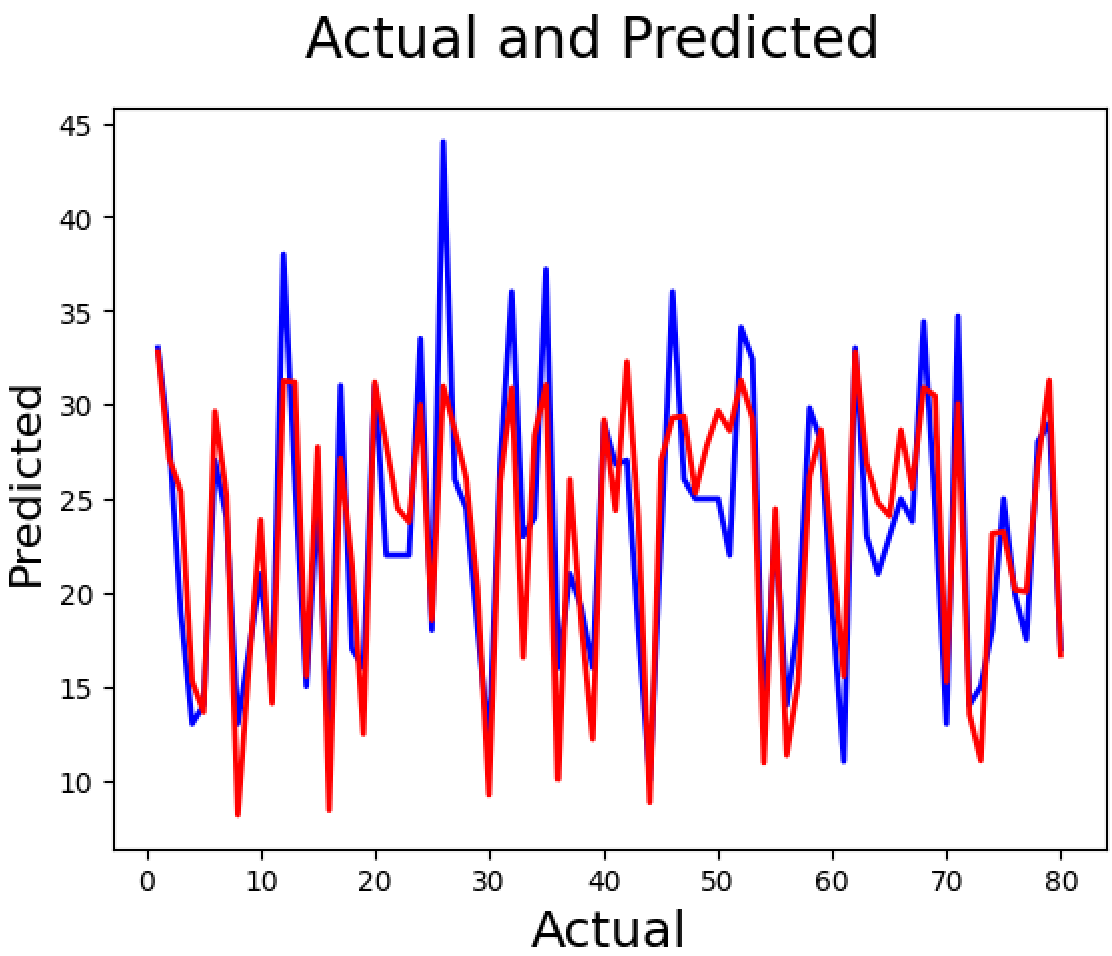
In [60]:
```python
import matplotlib.pyplot as plt

# Plot actual vs predicted values
plt.scatter(y_test, y_pred, color='blue', alpha=0.7)
plt.plot([y_test.min(), y_test.max()], [y_test.min(), y_test.max()], color='red', linestyle='--')  # Perfect prediction line
plt.title('Actual vs Predicted MPG')
plt.xlabel('Actual MPG')
plt.ylabel('Predicted MPG')
plt.grid(True)
plt.show()
```



Plotting Actual vs Predicted

In [61]:
```
c = [i for i in range(1,len(y_test)+1,1)]
fig = plt.figure()
plt.plot(c,y_test, color="blue", linewidth=2, linestyle="-")
plt.plot(c,y_pred, color="red",  linewidth=2, linestyle="-")
fig.suptitle('Actual and Predicted', fontsize=20)
plt.xlabel('Actual', fontsize=18)
plt.ylabel('Predicted', fontsize=16)
```

Out[61]:
```
Text(0, 0.5, 'Predicted')
```



Model Prediction

In [62]:
```
model.predict([[110,2720,3]])
```

```
c:\Users\abhij\AppData\Local\Programs\Python\Python313\Lib\site-packages\sklearn\utils\validation.py:2739: UserWarning: X does not have valid feature names, but LinearRegression was fitted with feature names
  warnings.warn(
```

Out[62]:
```
array([25.64064629])
```