Question 3 parts (b) through (h)

In [1]:
```
import pandas as pd
import statsmodels.api as sm
import matplotlib.pyplot as plt
import numpy as np
import re
```

In [2]:
```
# Load the CSV file into a DataFrame
import pandas as pd

df = pd.read_csv('auto.txt', sep='\t')

pd.set_option('display.max_rows', None)  # Display all rows
pd.set_option('display.max_columns', None)  # Display all columns

df.head()
```

Out[2]:

	mpg	cylinders	displacement	horsepower	weight	acceleration	year	origin	name
0	18.0 8 307.0 130.0 3504. 12...	chevrolet chevelle malibu	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	15.0 8 350.0 165.0 3693. 11...	buick skylark 320	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2	18.0 8 318.0 150.0 3436. 11...	plymouth satellite	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	16.0 8 304.0 150.0 3433. 12...	amc rebel sst	NaN	NaN	NaN	NaN	NaN	NaN	NaN
4	17.0 8 302.0 140.0 3449. 10...	ford torino	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Reading the auto.txt file with relevant data cleaning steps, realised after hit-and-trial.

In [3]:
```
file_path = 'auto.txt'

with open(file_path, 'r') as file:
    lines = file.readlines()

list_of_row_data = list()
columns_comma_separated = re.sub(r'\s+', ',', lines[0])
columns_list = columns_comma_separated.split(",")[:-1]

for line in lines[1:]:

    metrics = line.split("\t")[0]
    metrics_comma_separated_string = re.sub(r'\s+', ',', metrics)
    metrics_list = [float(value) if value!= "NA" else np.nan for value in metrics_c
    last_col = line.split("\t")[1]
```

```
    # print(metrics_list)
    # print(metrics)
    # print(last_col)

    metrics_list.append(last_col)
    list_of_row_data.append(metrics_list)


df = pd.DataFrame(list_of_row_data, columns=columns_list)
```

In [4]:
```
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
df.head()
```

Out[4]:

	mpg	cylinders	displacement	horsepower	weight	acceleration	year	origin	nam
0	18.0	8.0	307.0	130.0	3504.0	12.0	70.0	1.0	"chevrol chevel malibu"\
1	15.0	8.0	350.0	165.0	3693.0	11.5	70.0	1.0	"buic skyla 320"\
2	18.0	8.0	318.0	150.0	3436.0	11.0	70.0	1.0	"plymout satellite"\
3	16.0	8.0	304.0	150.0	3433.0	12.0	70.0	1.0	"amc reb sst"\
4	17.0	8.0	302.0	140.0	3449.0	10.5	70.0	1.0	"for torino"\

In [ ]:

In [ ]:

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
mpg             0
cylinders       0
displacement    0
horsepower      5
weight          0
acceleration    0
year            0
origin          0
name            0
dtype: int64
```

In [ ]:

In [6]:
```
# Create the independent/derived variable year-squared
```

```
df['year_sq'] = df['year']**2
```

In [7]:
```
df[ [ "year", "year_sq"  ] ].head()
```

Out[7]:

	year	year_sq
0	70.0	4900.0
1	70.0	4900.0
2	70.0	4900.0
3	70.0	4900.0
4	70.0	4900.0

Creating the uncentered regression model

In [8]:
```
X_0 = df[['year' , 'year_sq']]
y_0 = df['mpg']

# Add a constant, initialized to 1, to the independent variable. This will be the i
X_0 = sm.add_constant(X_0)
```

In [9]:
```
# Fit the linear regression model
model = sm.OLS(y_0, X_0).fit()

# Print the summary table of the regression model
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    mpg   R-squared:                       0.369
Model:                            OLS   Adj. R-squared:                  0.366
Method:                 Least Squares   F-statistic:                     115.4
Date:                Tue, 08 Oct 2024   Prob (F-statistic):           3.61e-40
Time:                        02:29:25   Log-Likelihood:                -1288.1
No. Observations:                 397   AIC:                             2582.
Df Residuals:                     394   BIC:                             2594.
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        577.2523    146.671      3.936      0.000     288.896     865.609
year         -15.8409      3.865     -4.098      0.000     -23.440      -8.242
year_sq        0.1123      0.025      4.419      0.000       0.062       0.162
==============================================================================
Omnibus:                       21.346   Durbin-Watson:                   0.809
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               18.130
Skew:                           0.446   Prob(JB):                     0.000116
Kurtosis:                       2.450   Cond. No.                     2.73e+06
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly spe
cified.
[2] The condition number is large, 2.73e+06. This might indicate that there are
strong multicollinearity or other numerical problems.
```

In [ ]:

In [10]:
```
correlation_coefficient = df['year'].corr(df['year_sq'])
correlation_coefficient
```

Out[10]:
```
0.999759011614808
```

In [11]:
```
year_mean = np.mean(df['year'])
year_mean
```

Out[11]:
```
75.99496221662469
```

Creating centered year

In [12]:
```
df['year_centered'] = df['year'] - year_mean
df['year_centered'].head()
```

Out[12]:
```
0   -5.994962
1   -5.994962
2   -5.994962
3   -5.994962
4   -5.994962
Name: year_centered, dtype: float64
```

In [ ]:

In [13]:
```
# Creating derived variable for centered year squared
df['year_centered_sq'] = df['year_centered']**2
df[ ['year_centered_sq', 'year_centered'] ].head()
```

Out[13]:

	year_centered_sq	year_centered
0	35.939572	-5.994962
1	35.939572	-5.994962
2	35.939572	-5.994962
3	35.939572	-5.994962
4	35.939572	-5.994962

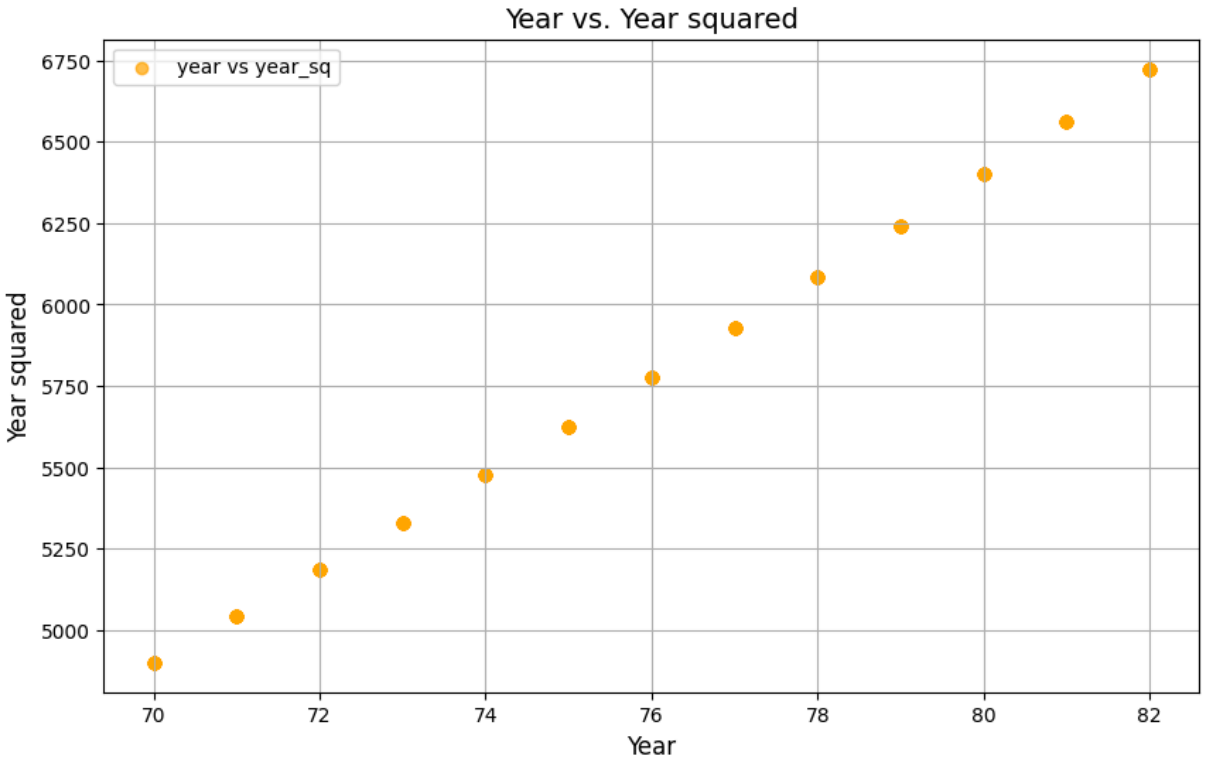
Calculating correlation

In [14]:
```
correlation_coefficient = df['year_centered'].corr(df['year_centered_sq'])
correlation_coefficient
```

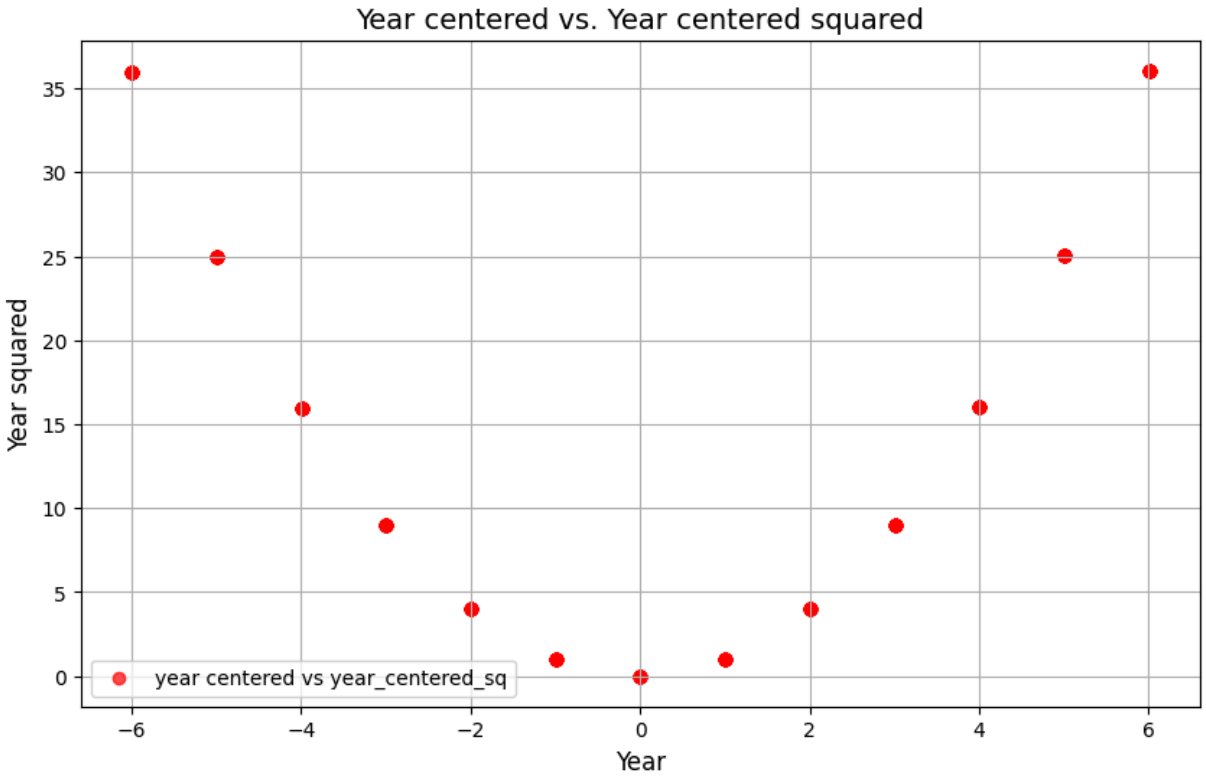
Out[14]:
```
0.014413995959565213
```

Creating required scatter plots

In [15]:
```
plt.figure(figsize=(10, 6))
plt.scatter(df['year'], df['year_sq'], color='orange', label='year vs year_sq', alp
# plt.scatter(df['year_centere'], df['year_centered_sq'], color='orange', label='Ap
plt.title('Year vs. Year squared', fontsize=14)
plt.xlabel('Year', fontsize=12)
plt.ylabel('Year squared', fontsize=12)
plt.legend()
plt.grid(True)
plt.show()
```



In [16]:
```
plt.figure(figsize=(10, 6))
plt.scatter(df['year_centered'], df['year_centered_sq'], color='red', label='year c
# plt.scatter(df['year_centere'], df['year_centered_sq'], color='orange', label='Ap
plt.title('Year centered vs. Year centered squared', fontsize=14)
plt.xlabel('Year', fontsize=12)
plt.ylabel('Year squared', fontsize=12)
plt.legend()
plt.grid(True)
plt.show()
```



Creating the centered model

In [17]:
```
X_1 = df[['year_centered' , 'year_centered_sq']]
y_1 = df['mpg']

# Add a constant, initialized to 1, to the independent variable. This will be the i
X_1 = sm.add_constant(X_1)
```

In [ ]:
```
```

In [18]:
```
# Fit the linear regression model
model = sm.OLS(y_1, X_1).fit()

# Print the summary table of the regression model
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                    mpg   R-squared:                       0.369
Model:                            OLS   Adj. R-squared:                  0.366
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No. Observations:                 397   AIC:                             2582.
Df Residuals:                     394   BIC:                             2594.
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         21.9906      0.466     47.214      0.000      21.075      22.906
year_centered  1.2278      0.085     14.469      0.000       1.061       1.395
year_centered_sq  0.1123      0.025      4.419      0.000       0.062       0.162
==============================================================================
Omnibus:                       21.346   Durbin-Watson:                   0.809
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               18.130
Skew:                           0.446   Prob(JB):                     0.000116
Kurtosis:                       2.450   Cond. No.                         27.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly spe
cified.
```

In [ ]:

As can be observed ->

beta2 = gamma2 i.e. beta2 = 0.1123

evaluating ->

- beta1 = gamma1 - 2 * gamma2 * year_mean

---

gamma2 = 0.1123

gamma1 = 1.2278

year_mean = 75.99

In [19]:
```
gamma1 = 1.2278
gamma2 = 0.1123
year_mean = 75.99

# b2= gamma2
# b1 = gamma1 - 2*gamma2

beta2 = gamma1 - 2*gamma2*year_mean
print(beta2, round(beta2,2))
```

```
-15.839553999999998 -15.84
```

As can be seen, the values derived for beta1 and beta2 in terms of gamma1 and gamma2 in the first part of the problem

have been cross-verified by the Betas produced by the OLS models for un-centered and centered model.

In [ ]:

In [ ]:

In [ ]:

In [ ]: