In [3]:
```
import numpy as np
import pickle
import pandas as pd
import os
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler, PolynomialFeatures
from sklearn.model_selection import KFold, cross_val_predict
from sklearn.linear_model import LinearRegression, Lasso, Ridge
from sklearn.metrics import r2_score
from sklearn.pipeline import Pipeline
```

In [20]:
```
data_path = "./cars.csv"
data = pd.read_csv(data_path, sep=',')
data.to_numpy()
print(data.shape)
```

```
(36, 5)
```

In [21]:
```
data.dtypes.value_counts()
```

Out[21]:
```
int64     3
object    2
dtype: int64
```

In [27]:
```
x_data = data[['Weight', 'Volume']].to_numpy()
y_data = data['CO2'].to_numpy()
```

In [28]:
```
x_data
```

Out[28]:
```
array([[ 790, 1000],
       [1160, 1200],
       [ 929, 1000],
       [ 865,  900],
       [1140, 1500],
       [ 929, 1000],
       [1109, 1400],
       [1365, 1500],
       [1112, 1500],
       [1150, 1600],
       [ 980, 1100],
       [ 990, 1300],
       [1112, 1000],
       [1252, 1600],
       [1326, 1600],
       [1330, 1600],
       [1365, 1600],
       [1280, 2200],
       [1119, 1600],
       [1328, 2000],
       [1584, 1600],
       [1428, 2000],
       [1365, 2100],
       [1415, 1600],
       [1415, 2000],
       [1465, 1500],
       [1490, 2000],
       [1725, 2000],
       [1523, 1600],
       [1705, 2000],
       [1605, 2100],
       [1746, 2000],
       [1235, 1600],
       [1390, 1600],
       [1405, 1600],
       [1395, 2500]], dtype=int64)
```

In [9]:
```
```

In [29]:
```
from sklearn.linear_model import LinearRegression

LR.fit(x_data, y_data)
```

Out[29]:
```
LinearRegression()
```
In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [30]:
```
predictedCO2 = LR.predict([[2300, 1300]])
```

In [31]:
```
LR.coef_
```

Out[31]:
```
array([0.00755095, 0.00780526])
```

In [32]:
```
predictedCO2
```

Out[32]:
```
array([107.2087328])
```

Done normal linear regression

In [2]:
```
import numpy as np
import pickle
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler, PolynomialFeatures
from sklearn.model_selection import KFold, cross_val_predict
from sklearn.linear_model import LinearRegression, Lasso, Ridge
from sklearn.metrics import r2_score
from sklearn.pipeline import Pipeline
```

In [3]:
```
data_path = "./cars.csv"
data = pd.read_csv(data_path, sep=',')

print(data.shape)
```

```
(36, 5)
```

In [7]:
```
X_data = data[['Weight', 'Volume']].to_numpy()
y_data = data['CO2'].to_numpy()
```

In [8]:
```
kf = KFold(shuffle=True, random_state=72018, n_splits=3)
```

In [9]:
```
for train_index, test_index in kf.split(X_data):
    print("Train index:", train_index[:10], len(train_index))
    print("Test index:",test_index[:10], len(test_index))
    print('')
```

```
Train index: [ 1  2  4  5  6  7  8 10 11 12] 24
Test index: [ 0  3  9 13 14 15 17 19 28 29] 12

Train index: [ 0  1  3  5  8  9 10 13 14 15] 24
Test index: [ 2  4  6  7 11 12 24 25 26 31] 12

Train index: [ 0  2  3  4  6  7  9 11 12 13] 24
Test index: [ 1  5  8 10 16 18 20 21 22 23] 12
```

In [13]:
```
scores = []
lr = LinearRegression()

for train_index, test_index in kf.split(X_data):
    X_train, X_test, y_train, y_test = (X_data[train_index, :],
                                        X_data[test_index, :],
                                        y_data[train_index],
                                        y_data[test_index])

    lr.fit(X_train, y_train)

    y_pred = lr.predict(X_test)

    score = r2_score(y_test, y_pred)

    scores.append(score)

scores
```

Out[13]:
```
[0.4976786744783538, 0.3781549390026453, -0.4963167598617597]
```

In [16]:
```
scores = []

lr = LinearRegression()
s = StandardScaler()

for train_index, test_index in kf.split(X_data):
    X_train, X_test, y_train, y_test = (X_data[train_index, :],
                                        X_data[test_index, :],
                                        y_data[train_index],
                                        y_data[test_index])

    X_train_s = s.fit_transform(X_train)

    lr.fit(X_train_s, y_train)

    X_test_s = s.transform(X_test)

    y_pred = lr.predict(X_test_s)

    score = r2_score(y_test, y_pred)

    scores.append(score)
print(scores)
```

```
[0.4976786744783538, 0.37815493900264563, -0.4963167598617597]
```

In [17]:
```
s = StandardScaler()
lr = LinearRegression()
estimator = Pipeline([("scaler", s),
                      ("regression", lr)])
```

In [18]:
```
predictions = cross_val_predict(estimator, X_data, y_data, cv=kf)
```

In [20]:
```
r2_score(y_data, predictions)
```

Out[20]:
```
0.2635012273172592
```

In [21]:
```
np.mean(scores)
```

Out[21]:
```
0.1265056178730799
```

In [22]:
```
alphas = np.geomspace(1e-9, 1e0, num=10)
alphas
```

Out[22]:
```
array([1.e-09, 1.e-08, 1.e-07, 1.e-06, 1.e-05, 1.e-04, 1.e-03, 1.e-02,
       1.e-01, 1.e+00])
```

In [23]:
```
scores = []
coefs = []
for alpha in alphas:
    las = Lasso(alpha=alpha, max_iter=100000)

    estimator = Pipeline([
        ("scaler", s),
        ("lasso_regression", las)])

    predictions = cross_val_predict(estimator, X_data, y_data, cv = kf)

    score = r2_score(y_data, predictions)

    scores.append(score)
```

In [24]:
```
list(zip(alphas,scores))
```

Out[24]:
```
[(1e-09, 0.2635012272629754),
 (1e-08, 0.2635012267748713),
 (1e-07, 0.26350122176396085),
 (1e-06, 0.2635012011949336),
 (1e-05, 0.2635005347849875),
 (0.0001, 0.26349679744487575),
 (0.001, 0.2634842554615041),
 (0.01, 0.2633569294305538),
 (0.1, 0.26189304939801694),
 (1.0, 0.23019380335703288)]
```

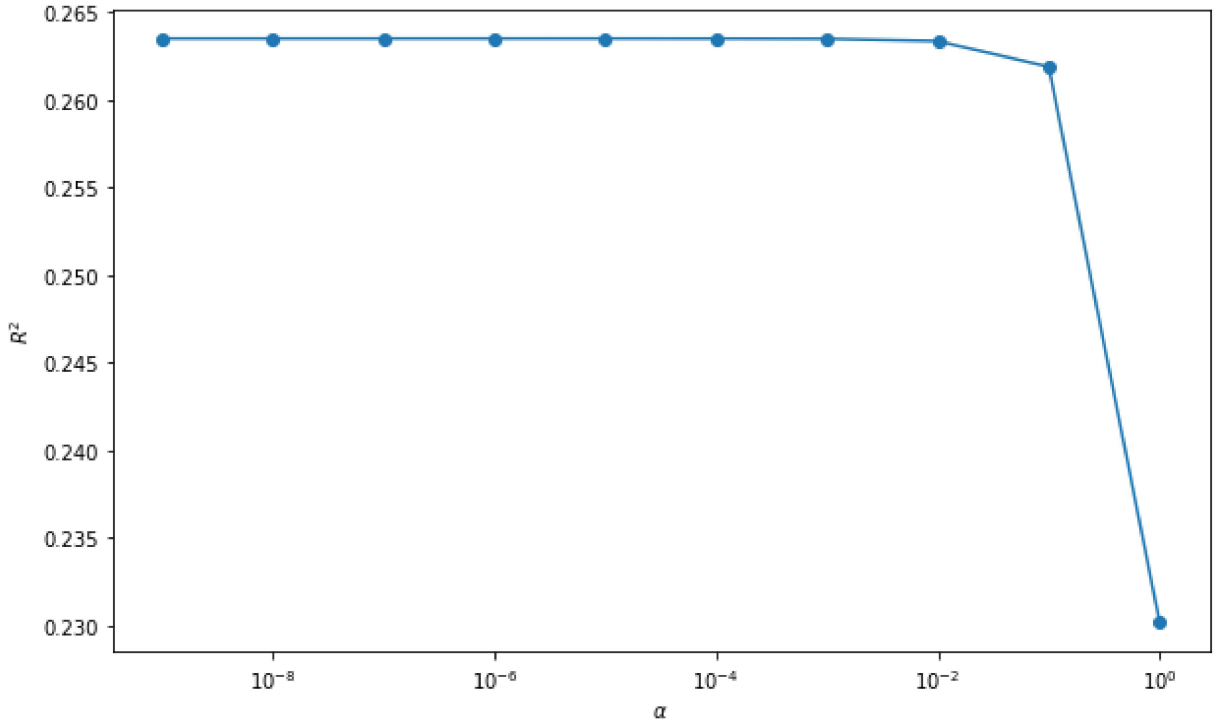
In [25]:
```
Lasso(alpha=1e-6).fit(X_data, y_data).coef_
```

Out[25]:
```
array([0.00755095, 0.00780526])
```

In [26]:
```
Lasso(alpha=1.0).fit(X_data, y_data).coef_
```

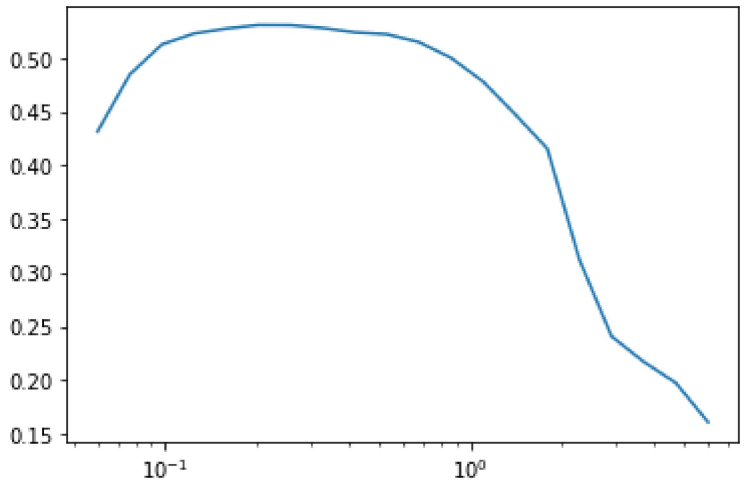
Out[26]:
```
array([0.00753002, 0.00780828])
```

In [27]:
```
plt.figure(figsize=(10,6))
plt.semilogx(alphas, scores, '-o')
plt.xlabel('$\\alpha$')
plt.ylabel('$R^2$');
```



In [28]:
```
pf = PolynomialFeatures(degree=3)

scores = []
alphas = np.geomspace(0.06, 6.0, 20)
for alpha in alphas:
    las = Lasso(alpha=alpha, max_iter=100000)

    estimator = Pipeline([
        ("scaler", s),
        ("make_higher_degree", pf),
        ("lasso_regression", las)])

    predictions = cross_val_predict(estimator, X_data, y_data, cv = kf)

    score = r2_score(y_data, predictions)

    scores.append(score)
```

In [29]:
```
plt.semilogx(alphas, scores);
```



In [30]:
```
best_estimator = Pipeline([
                    ("scaler", s),
                    ("make_higher_degree", PolynomialFeatures(degree=2)),
                    ("lasso_regression", Lasso(alpha=0.03))])

best_estimator.fit(X_data, y_data)
best_estimator.score(X_data, y_data)
```

Out[30]:
```
0.5366706865383412
```

In [31]:
```
best_estimator.named_steps["lasso_regression"].coef_
```

Out[31]:
```
array([ 0.        ,  2.04252234,  3.26959714,  2.21906509, -0.66592006,
        1.28836198])
```

In [ ]:
```

```