```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np

df = pd.read_csv('ENB2012_data.csv')

df
```

	X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2
0	0.98	514.5	294.0	110.25	7.0	2.0	0.0	0.0	15.55	21.33
1	0.98	514.5	294.0	110.25	7.0	3.0	0.0	0.0	15.55	21.33
2	0.98	514.5	294.0	110.25	7.0	4.0	0.0	0.0	15.55	21.33
3	0.98	514.5	294.0	110.25	7.0	5.0	0.0	0.0	15.55	21.33
4	0.90	563.5	318.5	122.50	7.0	2.0	0.0	0.0	20.84	28.28
...	...	...	...	...	...	...	...	...	...	...
1291	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1292	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1293	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1294	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1295	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

```
[1296 rows x 10 columns]

df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1296 entries, 0 to 1295
Data columns (total 10 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   X1      768 non-null    float64
 1   X2      768 non-null    float64
 2   X3      768 non-null    float64
 3   X4      768 non-null    float64
 4   X5      768 non-null    float64
 5   X6      768 non-null    float64
 6   X7      768 non-null    float64
 7   X8      768 non-null    float64
 8   Y1      768 non-null    float64
 9   Y2      768 non-null    float64
dtypes: float64(10)
memory usage: 101.4 KB

df.shape

(1296, 10)

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

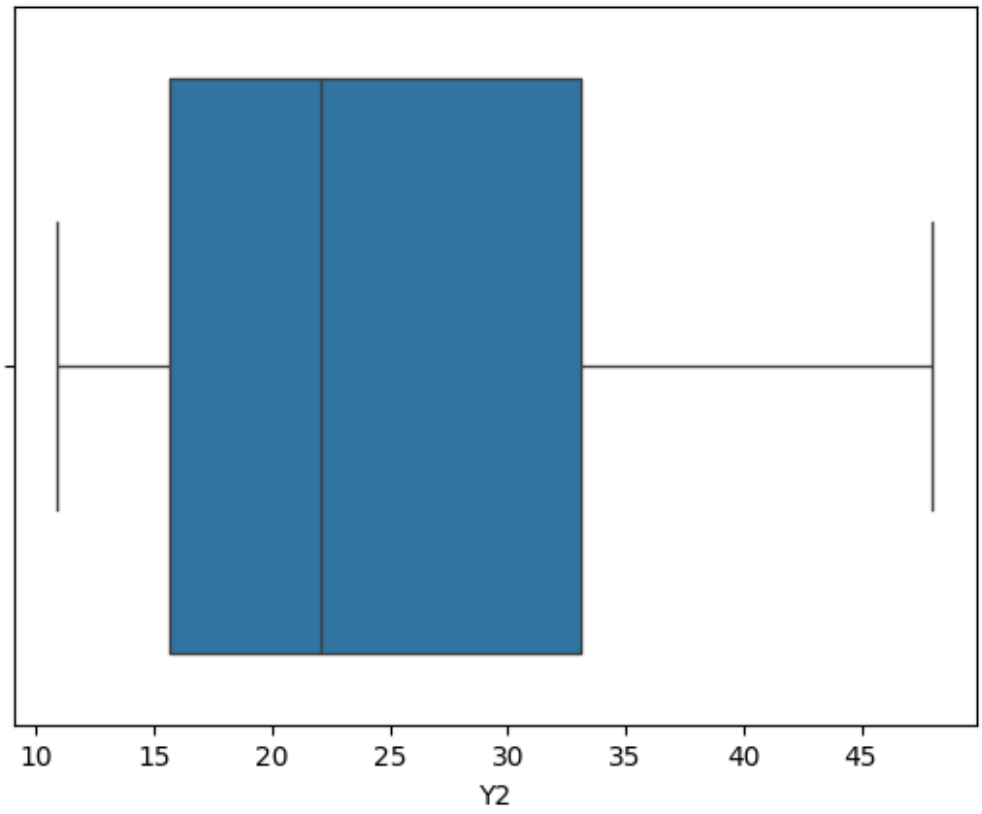
```
X1    528
X2    528
X3    528
X4    528
X5    528
X6    528
X7    528
X8    528
Y1    528
Y2    528
dtype: int64
```

So we will be dropping the NaN values

```
df = df.dropna()
print(f'The number of null values now in every column is
{df.isnull().sum().sum()}')

The number of null values now in every column is 0
```

Two target variables are heating load and the cooling load. We are supposed to predict the Heating Load

```
sns.boxplot(x='Y2', data = df) #By continously changing the values of
the x attribute inside the boxplot paranthesis we learned that there
are no outliers which are needed to be handled

<Axes: xlabel='Y2'>
```



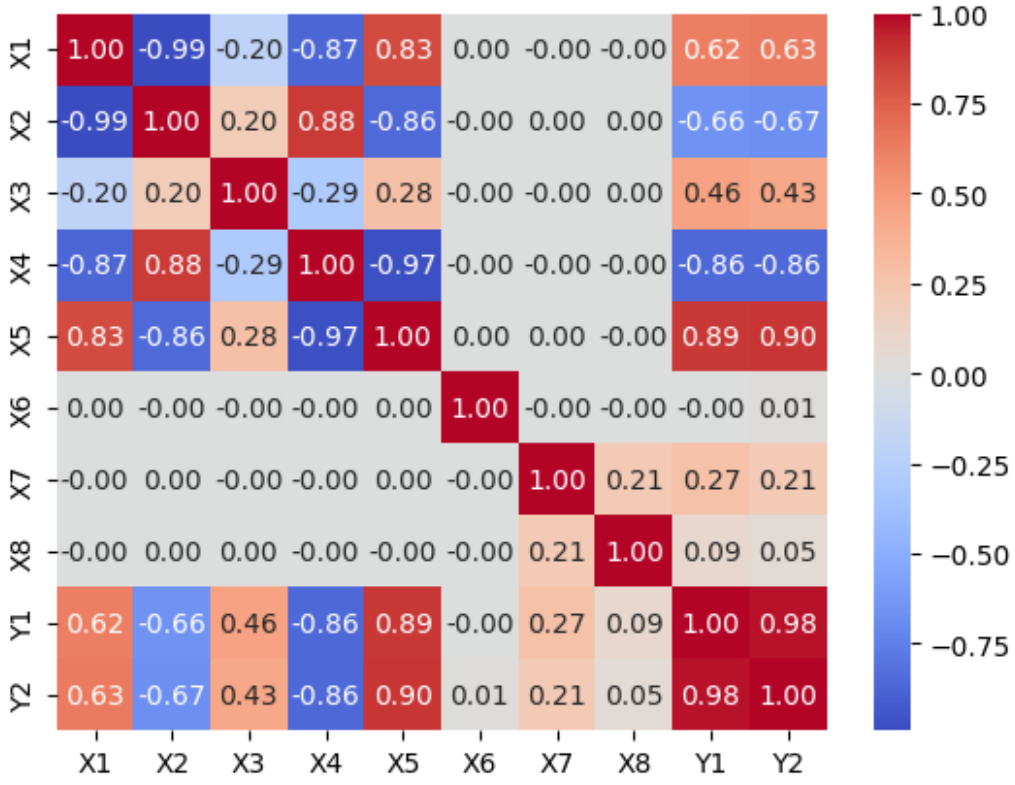

```
import warnings
with warnings.catch_warnings():
    warnings.simplefilter('ignore')

correlation_matrix = df.corr()
print(correlation_matrix)
sns.heatmap(correlation_matrix, annot =  True, cmap='coolwarm', fmt
='.2f')
```

```
               X1            X2            X3            X4
X5  \
X1  1.000000e+00 -9.919015e-01 -2.037817e-01 -8.688234e-01  8.277473e-
01
X2 -9.919015e-01  1.000000e+00  1.955016e-01  8.807195e-01 -8.581477e-
01
X3 -2.037817e-01  1.955016e-01  1.000000e+00 -2.923165e-01  2.809757e-
01
X4 -8.688234e-01  8.807195e-01 -2.923165e-01  1.000000e+00 -9.725122e-
01
X5  8.277473e-01 -8.581477e-01  2.809757e-01 -9.725122e-01
1.000000e+00
X6  4.678592e-17 -3.459372e-17 -2.429499e-17 -5.830058e-17  4.492205e-
```

```
17
X7 -2.960552e-15  3.636925e-15 -8.567455e-17 -1.759011e-15  1.489134e-
17
X8 -7.107006e-16  2.438409e-15  2.067384e-16 -1.078071e-15 -2.920613e-
17
Y1  6.222722e-01 -6.581202e-01  4.556712e-01 -8.618283e-01  8.894307e-
01
Y2  6.343391e-01 -6.729989e-01  4.271170e-01 -8.625466e-01  8.957852e-
01
```

	X6	X7	X8	Y1	Y2
X1	4.678592e-17	-2.960552e-15	-7.107006e-16	0.622272	0.634339
X2	-3.459372e-17	3.636925e-15	2.438409e-15	-0.658120	-0.672999
X3	-2.429499e-17	-8.567455e-17	2.067384e-16	0.455671	0.427117
X4	-5.830058e-17	-1.759011e-15	-1.078071e-15	-0.861828	-0.862547
X5	4.492205e-17	1.489134e-17	-2.920613e-17	0.889431	0.895785
X6	1.000000e+00	-9.406007e-16	-2.549352e-16	-0.002587	0.014290
X7	-9.406007e-16	1.000000e+00	2.129642e-01	0.269841	0.207505
X8	-2.549352e-16	2.129642e-01	1.000000e+00	0.087368	0.050525
Y1	-2.586534e-03	2.698410e-01	8.736759e-02	1.000000	0.975862
Y2	1.428960e-02	2.075050e-01	5.052512e-02	0.975862	1.000000

```
<Axes: >
```



There is strong correlation between Y1,Y2 and X1,X2,X3,X4,X5

```
df.head(20)
```

	X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2
0	0.98	514.5	294.0	110.25	7.0	2.0	0.0	0.0	15.55	21.33
1	0.98	514.5	294.0	110.25	7.0	3.0	0.0	0.0	15.55	21.33
2	0.98	514.5	294.0	110.25	7.0	4.0	0.0	0.0	15.55	21.33
3	0.98	514.5	294.0	110.25	7.0	5.0	0.0	0.0	15.55	21.33
4	0.90	563.5	318.5	122.50	7.0	2.0	0.0	0.0	20.84	28.28
5	0.90	563.5	318.5	122.50	7.0	3.0	0.0	0.0	21.46	25.38
6	0.90	563.5	318.5	122.50	7.0	4.0	0.0	0.0	20.71	25.16
7	0.90	563.5	318.5	122.50	7.0	5.0	0.0	0.0	19.68	29.60
8	0.86	588.0	294.0	147.00	7.0	2.0	0.0	0.0	19.50	27.30
9	0.86	588.0	294.0	147.00	7.0	3.0	0.0	0.0	19.95	21.97
10	0.86	588.0	294.0	147.00	7.0	4.0	0.0	0.0	19.34	23.49
11	0.86	588.0	294.0	147.00	7.0	5.0	0.0	0.0	18.31	27.87
12	0.82	612.5	318.5	147.00	7.0	2.0	0.0	0.0	17.05	23.77
13	0.82	612.5	318.5	147.00	7.0	3.0	0.0	0.0	17.41	21.46
14	0.82	612.5	318.5	147.00	7.0	4.0	0.0	0.0	16.95	21.16
15	0.82	612.5	318.5	147.00	7.0	5.0	0.0	0.0	15.98	24.93
16	0.79	637.0	343.0	147.00	7.0	2.0	0.0	0.0	28.52	37.73
17	0.79	637.0	343.0	147.00	7.0	3.0	0.0	0.0	29.90	31.27
18	0.79	637.0	343.0	147.00	7.0	4.0	0.0	0.0	29.63	30.93
19	0.79	637.0	343.0	147.00	7.0	5.0	0.0	0.0	28.75	39.44

```
independant_col = ['X1','X2','X3','X4','X5']
target_col=['Y1','Y2']
x = df[independant_col]
y =df[target_col]

from sklearn import linear_model
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression, Ridge, Lasso
from sklearn.metrics import mean_squared_error, r2_score

x_train,x_test,y_train,y_test= train_test_split(x,y,test_size =
0.2,random_state = 42)

x_train.shape
```

```
(614, 5)
```

```
x_test.shape
```

```
(154, 5)
```

```
614/154
```

```
3.987012987012987
```

Therefore the given data has been successfully splited into desired ratio

```
lr_model = LinearRegression()
lr_model.fit(x_train, y_train)
Y_pred_lr = lr_model.predict(x_test)

# Ridge Regression
ridge_model = Ridge(alpha=1.0)
ridge_model.fit(x_train, y_train)
Y_pred_ridge = ridge_model.predict(x_test)

# Lasso Regression
lasso_model = Lasso(alpha=1.0)
lasso_model.fit(x_train, y_train)
Y_pred_lasso = lasso_model.predict(x_test)
```

The Scores due to the models used are caluclated below

```
ridge_model.score(x_test,y_test)
```

```
0.8512285840905137
```

```
lr_model.score(x_test,y_test)
```

```
0.8516925183420243
```

```
lasso_model.score(x_test,y_test)
```

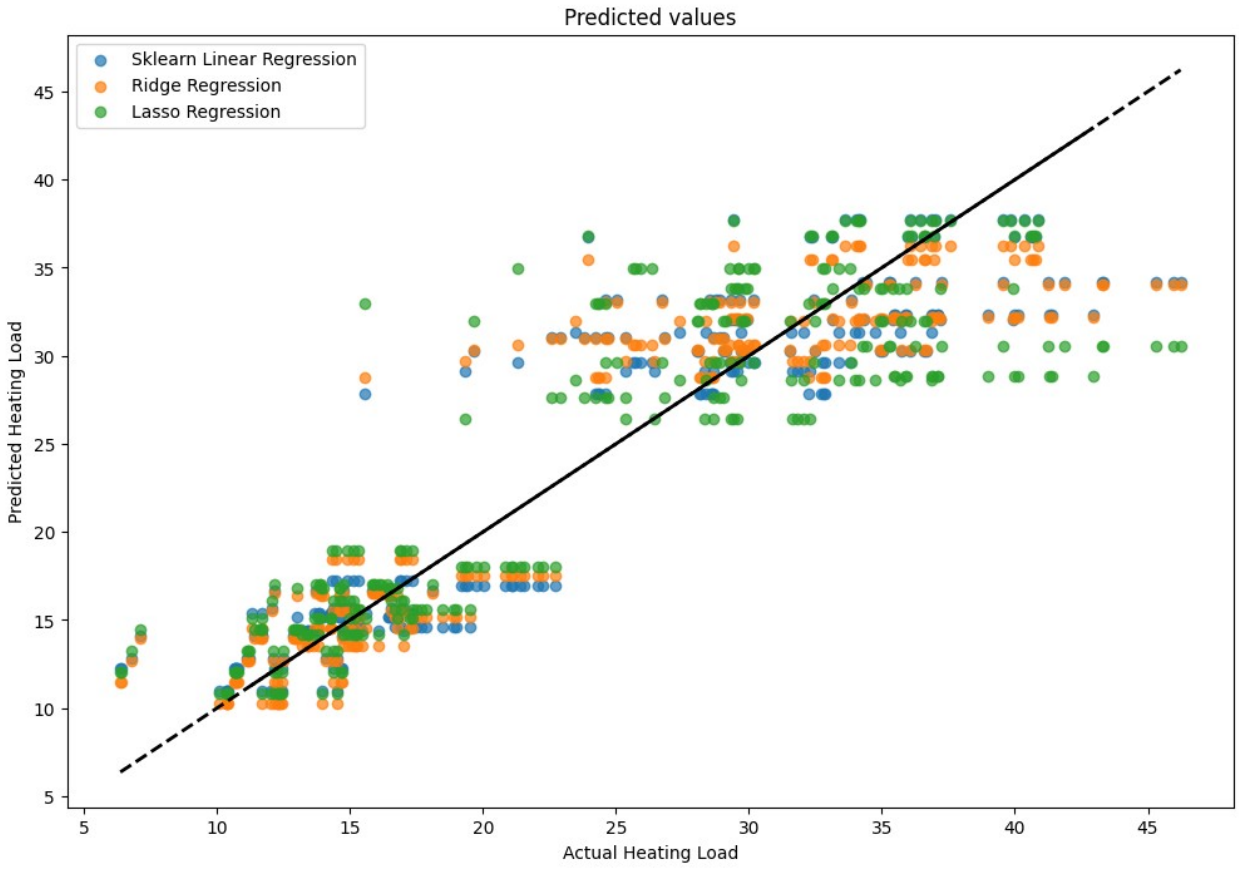
```
0.7813668369997759
```

```
metrics = {}
def evaluate_model(y_true, y_pred, model_name):
    r2 = r2_score(y_true, y_pred)
    mse = mean_squared_error(y_true, y_pred)
    rmse = np.sqrt(mse)
    metrics[model_name] = {"R2 Score": r2, "MSE": mse, "RMSE": rmse}


evaluate_model(y_test, Y_pred_lr, "Sklearn Linear Regression")
evaluate_model(y_test, Y_pred_ridge, "Ridge Regression")
evaluate_model(y_test, Y_pred_lasso, "Lasso Regression")
```

Plot predicted

```


plt.figure(figsize=(12, 8))
plt.scatter(y_test, Y_pred_lr, label="Sklearn Linear Regression",
alpha=0.7)
plt.scatter(y_test, Y_pred_ridge, label="Ridge Regression", alpha=0.7)
plt.scatter(y_test, Y_pred_lasso, label="Lasso Regression", alpha=0.7)
plt.plot([y_test.min(), y_test.max()], [y_test.min(), y_test.max()],
'k--', lw=2)
```

```
plt.xlabel("Actual Heating Load")
plt.ylabel("Predicted Heating Load")
plt.legend()
plt.title("Predicted values")
plt.show()

# Insights and suggestions
important_features = lr_model.coef_
feature_importance = pd.Series(important_features,
index=x.columns).sort_values(ascending=False)
print("Feature importance for heating load:")
print(feature_importance)
```




```
---------------------------------------------------------------------------
-----
ValueError                                Traceback (most recent call
last)
Cell In[75], line 14
     12 # Insights and suggestions
     13 important_features = lr_model.coef_
---> 14 feature_importance = pd.Series(important_features,
index=x.columns).sort_values(ascending=False)
```

```
     15 print("Feature importance for heating load:")
     16 print(feature_importance)

File ~\AppData\Local\Programs\Python\Python313\Lib\site-packages\
pandas\core\series.py:575, in Series.__init__(self, data, index,
dtype, name, copy, fastpath)
    573     index = default_index(len(data))
    574 elif is_list_like(data):
--> 575     com.require_length_match(data, index)
    577 # create/copy the manager
    578 if isinstance(data, (SingleBlockManager, SingleArrayManager)):

File ~\AppData\Local\Programs\Python\Python313\Lib\site-packages\
pandas\core\common.py:573, in require_length_match(data, index)
    569 """
    570 Check the length of data matches the length of the index.
    571 """
    572 if len(data) != len(index):
--> 573     raise ValueError(
    574         "Length of values "
    575         f"({len(data)}) "
    576         "does not match length of index "
    577         f"({len(index)})"
    578     )

ValueError: Length of values (2) does not match length of index (5)
```

SUGGESTION

**1. Focus on improving insulation and wall design as wall area significantly impacts heating load.

1. Optimize glazing area and its distribution to balance natural light and thermal efficiency.
2. Enhance roof area design to minimize heat loss in cold climates.
3. Consider relative compactness to reduce surface area exposure to the external environment.**