DEPARTMENT OF INFORMATICS

INF 491/791

SEMESTER TEST **DATE: 2023-10-06**

Examiners	:	Mr Ridewaan Hanslo Mr. Mike Wa Nkongolo	**Time**	:	180 min
Moderator / External Examiner	:	Mr. Siyabonga Mhlongo University of the Johannesburg	**Marks**	:	70

Student Number								Surname	Initials
-	-	-	-	-	-	-	-	MEMO	--

Question Section	Module outcomes (as in Study Guide)						Marks allocated	Maximum mark
	MO1	MO2	MO3	MO4	MO5	MO6		
Section A	X	X	X	X		X	35	35
Section B	X	X	X	X		X	35	35
Total							70	70

Instructions

1. This paper consists of 2 sections with one question per section (sub-sets of instructions) each.
2. Answer all the questions – there are no optional questions.
3. Please read all questions, instructions and sub-sets of tasks very carefully.
4. After completing work on a relevant question, please upload the file(s) required to be uploaded to the correct upload area. In other words, each section will mention what files to upload and how to upload them.

The University of Pretoria commits itself to producing academic work of integrity. I affirm that I am aware of and have read the Rules and Policies of the University, more specifically the Disciplinary Procedure and the Tests and Examinations Rules, which prohibit any unethical, dishonest or improper conduct during tests, assignments, examinations and/or any other forms of assessment. I am aware that no student or any other person may assist or attempt to assist another student, or obtain help, or attempt to obtain help from another student or any other person during tests, assessments, assignments, examinations and/or any other forms of assessment.

SECTION A – CASE STUDY (STUDENT MENTAL HEALTH)

For Section A, you need to complete **one question**; a Case Study **question**. You will be using **Jupyter Lab** to create a **Jupyter Notebook**. As done for your assignments and demonstrated in lectures, you need to run "**jupyter lab**" in the windows command prompt.

The dataset to be used for this question is "**Student Mental health.csv**".

Once you have completed the question in this section, **only** upload the **Jupyter Notebook (.ipynb)** to the **Section A upload slot**..

(IMPORTANT: DO NOT UPLOAD ZIP, TAR, RAR or SLN files)

SECTION A - QUESTION (STUDENT MENTAL HEALTH) (35 MARKS)

In this case study, you will explore a dataset of students to examine their academic situation and mental health.

The Dataset description is as follows:

Dataset Description

Attribute	Explanation
Timestamp	Date and time when data was recorded.
Gender	Gender of the student (e.g., Male, Female).
Age	Age of the student.
Course	Academic program or major of the student.
Current Year	Current academic year or level of the student.
CGPA	Cumulative Grade Point Average (academic performance).
Marital Status	Marital status of the student (e.g., Married, Single).
Depression Status	Indicates if the student is experiencing depression (1 for Yes, 0 for No).
Anxiety Status	Indicates if the student is experiencing anxiety (1 for Yes, 0 for No).
Panic Status	Indicates if the student is experiencing panic attacks (1 for Yes, 0 for No).
Treatment Need	Indicates if the student believes they need treatment for mental health (1 for Yes, 0 for No).

You will focus on the following key processes:

- **1.1 Name your columns as follows: [2 Marks]**
  - 'Timestamp', 'Gender', 'Age', 'Course', 'Year', 'CGPA', 'Status', 'Depression', 'Anxiety', 'Panic', 'Treatment'

	Timestamp	Gender	Age	Course	Year	CGPA	Status	Depression	Anxiety	Panick	Treatment
0	8/7/2020 12:02	Female	18.0	Engineering	year 1	3.00 - 3.49	No	Yes	No	Yes	No
1	8/7/2020 12:04	Male	21.0	Islamic education	year 2	3.00 - 3.49	No	No	Yes	No	No
2	8/7/2020 12:05	Male	19.0	BIT	Year 1	3.00 - 3.49	No	Yes	Yes	Yes	No
3	8/7/2020 12:06	Female	22.0	Laws	year 3	3.00 - 3.49	Yes	Yes	No	No	No
4	8/7/2020 12:13	Male	23.0	Mathemathics	year 4	3.00 - 3.49	No	No	No	No	No
...	...	...	...	...	...	...	...	...	...	...	...
96	13/07/2020 19:56:49	Female	21.0	BCS	year 1	3.50 - 4.00	No	No	Yes	No	No
97	13/07/2020 21:21:42	Male	18.0	Engineering	Year 2	3.00 - 3.49	No	Yes	Yes	No	No
98	13/07/2020 21:22:56	Female	19.0	Nursing	Year 3	3.50 - 4.00	Yes	Yes	No	Yes	No
99	13/07/2020 21:23:57	Female	23.0	Pendidikan Islam	year 4	3.50 - 4.00	No	No	No	No	No
100	18/07/2020 20:16:21	Male	20.0	Biomedical science	Year 2	3.00 - 3.49	No	No	No	No	No

101 rows × 11 columns

Fig 1. Example Output

- **1.2 Use LabelEncoder to transform the following categorical variables into numerical values: [3 Marks]**
  - Timestamp
  - Gender

- Status
- Depression
- Anxiety
- Panic
- Treatment

	Timestamp	Gender	Age	Course	Year	CGPA	Status	Depression	Anxiety	Panick	Treatment
0	23	0	18.0	Engineering	year 1	3.00 - 3.49	0	1	0	1	0
1	24	1	21.0	Islamic education	year 2	3.00 - 3.49	0	0	1	0	0
2	25	1	19.0	BIT	Year 1	3.00 - 3.49	0	1	1	1	0
3	26	0	22.0	Laws	year 3	3.00 - 3.49	1	1	0	0	0
4	27	1	23.0	Mathemathics	year 4	3.00 - 3.49	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...
96	18	0	21.0	BCS	year 1	3.50 - 4.00	0	0	1	0	0
97	19	1	18.0	Engineering	Year 2	3.00 - 3.49	0	1	1	0	0
98	20	0	19.0	Nursing	Year 3	3.50 - 4.00	1	1	0	1	0
99	21	0	23.0	Pendidikan Islam	year 4	3.50 - 4.00	0	0	0	0	0
100	22	1	20.0	Biomedical science	Year 2	3.00 - 3.49	0	0	0	0	0

101 rows × 11 columns

Fig 2. Example Output

- **1.3 Create a bar plot to show the course distribution per CGPA. Add labels and a title to display the plot. [5 Marks]**

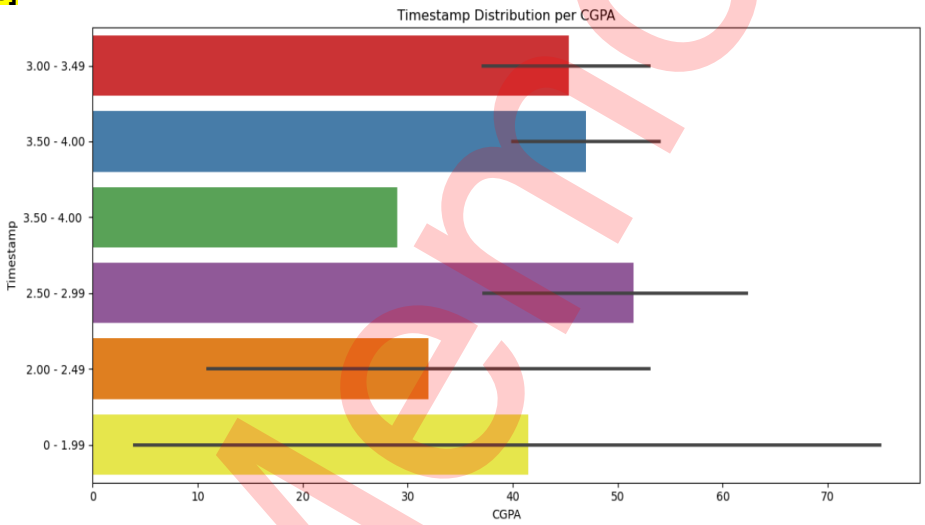


Fig 3. Example Output

- **1.4 Create a bar plot to show the course distribution with the highest CGPA. [5 Marks]**

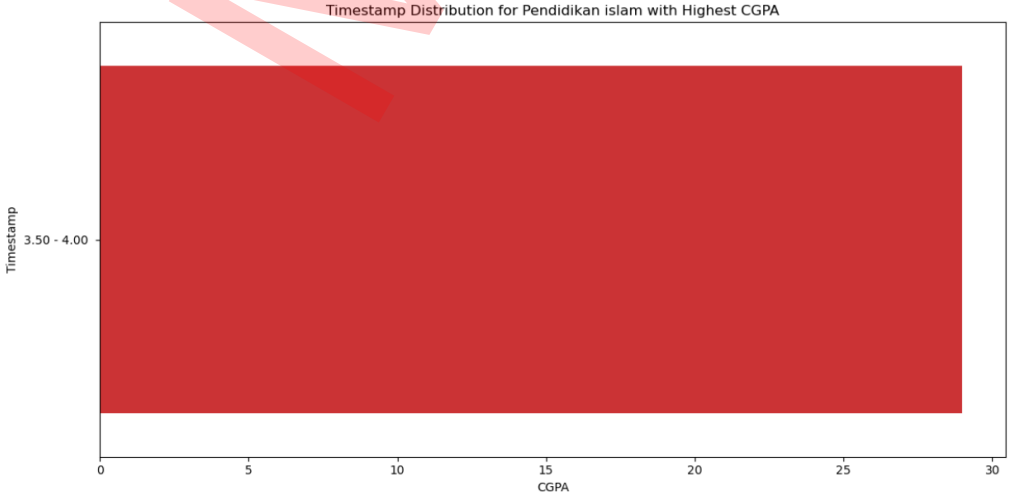


Fig 4. Example Output

- **1.5 Group the data by 'Course' and calculate the sum of 'Depression' to find the course with the most depressed students as well as the number of depressed students. [5 Marks]**

- *Expected output example*: “The course with the most depressed students is '?' with ‘?’ depressed students.

- **1.6 Find the most depressed gender in the course with the most depressed students. [5 Marks]**
  - *Expected output example*: “The most depressed gender among students in the '?' course is '?'.

- **1.7 Find the course and gender with the most students wanting treatment. [10 Marks]**
  - *Expected output example*: “The course and gender that need the most treatment is '?' and '?'”.

SOLUTION SECTION A

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
from sklearn.preprocessing import StandardScaler

# Phase 1: Data Collection (e.g., Student Mental health.csv)

pd.set_option("expand_frame_repr", False)
df= pd.read_csv('Student Mental health.csv')
df.columns =
['Timestamp','Gender','Age','Course','Year','CGPA','Status','Depression','Anxiety','Panic','Treatment']
from sklearn import preprocessing

# transformation of categorical to numeric
lab_encoder = preprocessing.LabelEncoder()
df['Timestamp'] = lab_encoder.fit_transform(df['Timestamp'])
df['Gender'] = lab_encoder.fit_transform(df['Gender'])
df['Status'] = lab_encoder.fit_transform(df['Status'])
df['Depression'] = lab_encoder.fit_transform(df['Depression'])
df['Anxiety'] = lab_encoder.fit_transform(df['Anxiety'])
df['Panic'] = lab_encoder.fit_transform(df['Panic'])
df['Treatment'] = lab_encoder.fit_transform(df['Treatment'])

# Set the figure size
plt.figure(figsize=(12, 6))
 #Note: Female =0 and Male=1

# Create a bar plot to show the course distribution per CGPA
sns.barplot(data=df, x='Timestamp', y='CGPA', palette='Set1')

# Add labels and title
plt.xlabel('CGPA')
plt.ylabel('Timestamp')
plt.title('Timestamp Distribution per CGPA')

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

# Find the course with the highest CGPA
course_with_highest_cgpa = df[df['CGPA'] == df['CGPA'].max()]['Course'].values[0]

# Filter the DataFrame to include only the rows with the highest CGPA course
df_filtered = df[df['Course'] == course_with_highest_cgpa]

# Set the figure size
plt.figure(figsize=(12, 6))

# Create a bar plot to show the course distribution per CGPA
sns.barplot(data=df_filtered, x='Timestamp', y='CGPA', palette='Set1')
```

```
# Add labels and title
plt.xlabel('CGPA')
plt.ylabel('Timestamp')
plt.title(f'Timestamp Distribution for {course_with_highest_cgpa} with Highest CGPA')

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

# Group the data by 'Course' and calculate the sum of 'Depression'
course_depression_counts = df.groupby('Course')['Depression'].sum()

# Find the course with the most depressed students
most_depressed_course = course_depression_counts.idxmax()
most_depressed_students = course_depression_counts.max()

print(f"The course with the most depressed students is '{most_depressed_course}' with
{most_depressed_students} depressed students.")

# Group the data by 'Course' and calculate the sum of 'Depression'
course_depression_counts = df.groupby('Course')['Depression'].sum()

# Find the course with the most depressed students
most_depressed_course = course_depression_counts.idxmax()

# Filter the DataFrame to include only the students in the most depressed course
most_depressed_students_df = df[df['Course'] == most_depressed_course]

# Group the filtered data by 'Gender' and calculate the sum of 'Depression'
gender_depression_counts = most_depressed_students_df.groupby('Gender')['Depression'].sum()

# Find the gender with the most depressed students
most_depressed_gender = gender_depression_counts.idxmax()

print(f"The most depressed gender among students in the '{most_depressed_course}' course is
'{most_depressed_gender}'.")

# Filter the DataFrame to include only students who want treatment (Treatment == 1)
students_wanting_treatment = df[df['Treatment'] == 1]

# Group the filtered data by 'Course' and 'Gender' and calculate the count of students wanting treatment
treatment_counts = students_wanting_treatment.groupby(['Course', 'Gender']).size().reset_index(name='Count')

# Find the course and gender with the most students wanting treatment
most_wanted_course_gender = treatment_counts[treatment_counts['Count'] == treatment_counts['Count'].max()]

most_wanted_course = most_wanted_course_gender['Course'].values[0]
most_wanted_gender = most_wanted_course_gender['Gender'].values[0]

print(f"The course and gender that need the most treatment are '{most_wanted_course}' and
'{most_wanted_gender}'.")
```


SECTION A TOTAL **35**

SECTION B – CASE STUDY (PROPERTY PRICES)

For Section B, you need to complete **one question**; a Case Study **question**. You will be using **Jupyter Lab** to create a **Jupyter Notebook**. As done for your assignments and demonstrated in lectures, you need to run "**jupyter lab**" in the windows command prompt.

The dataset to be used for this question is "**property_data.csv**".

Once you have completed the question in this section, **only** upload the **Jupyter Notebook (.ipynb)** to the **Section B upload slot**. *Therefore, you do not need to upload or make changes to the prepped "**property_data.csv**" file, you just proceed with the required question tasks in your* **Jupyter Notebook (.ipynb)**.

(IMPORTANT: DO NOT UPLOAD ZIP, TAR, RAR or SLN files)

SECTION B - QUESTION (PROPERTY PRICES) (35 MARKS)

For this case study, you need to apply statistical analysis and machine learning techniques to apply a multivariate linear regressions models to explain the variance of the house prices with the dataset features.

The Dataset Description is as follows:

Dataset Description

Features

- CRIM: per capita crime rate by town
- ZN: proportion of residential land zoned for lots over 25,000 sq.ft.
- INDUS: proportion of non-retail business acres per town
- CHAS: Charles River dummy variable (= 1 if tract bounds river; 0 otherwise)
- NOX: nitric oxides concentration (parts per 10 million)
- RM: average number of rooms per dwelling
- AGE: proportion of owner-occupied units built prior to 1940
- DIS: weighted distances to five Boston employment centres
- RAD: index of accessibility to radial highways
- TAX: full-value property-tax rate per 10,000 dollars
- PTRATIO: pupil-teacher ratio by town
- LSTAT: % lower status of the population

Target

- MEDV: Median value (Property Price) of owner-occupied homes in 1000's dollars

You must complete the following tasks:

- **1.1 Data Exploration: Data loading and display [2 Marks]**
  - Load the csv and display the data via the Data frame.

- **1.2 Data Exploration: Perform descriptive analysis on data [1 Mark]**
  - The mean, min, max, standard deviation, etc. should be visible.

- **1.3 Data Visualization: Visualize the Property Price density [3 Marks]**
  - Use a histogram displaying the ***property price*** with 40 bins, and the normality distribution curve.

- **1.4 Statistical Analysis: Correlation [8 Marks]**
  - Generate a correlation table for the dataset variables relationships. (1 mark)
  - Generate a correlation heatmap figure displaying the dataset variables relationships. The figure width should be 12 and height of 6. Furthermore, the x and y axis label sizes should be 8. (6 marks)
  - Generate a scatterplot correlation with regression line between the property price and room number variables (1 mark).

- **1.5 Machine Learning: Training and Test Dataset Split [5 Marks]**
  - Create an 80% train and 20% test dataset split, applying shuffling.

- **1.6 Machine Learning: Multivariable Regression [5 Marks]**
  - Develop the Linear Regression model fitting the split data. Furthermore, you need to display training and test data predictive accuracy, as well as the Intercept and Coefficients.

- **1.7 Data Transformations: Log Transformation [6 Marks]**
  - Display the skewness value of the property price. (1 mark)
  - Transform the property price and display the skewness value. (2 marks)
  - Plot the property price with the log transformation normality distribution curve using a histogram with a title: "*Property price with log transformation*". (3 marks)

- **1.8 Machine Learning: Log Transformation Regression Model [5 Marks]**
  - Develop the Log Transformation Linear Regression model fitting the split data. Furthermore, you need to display training and test data predictive accuracy, as well as the Intercept and Coefficients.

SOLUTION SECTION B

```
# 35 Marks in Total for Section B

from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression

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

%matplotlib inline
```

```
# 2 marks in Total
#   1 mark for the data reading
#   1 mark to display the data
data = pd.read_csv('property_data.csv')
data
```

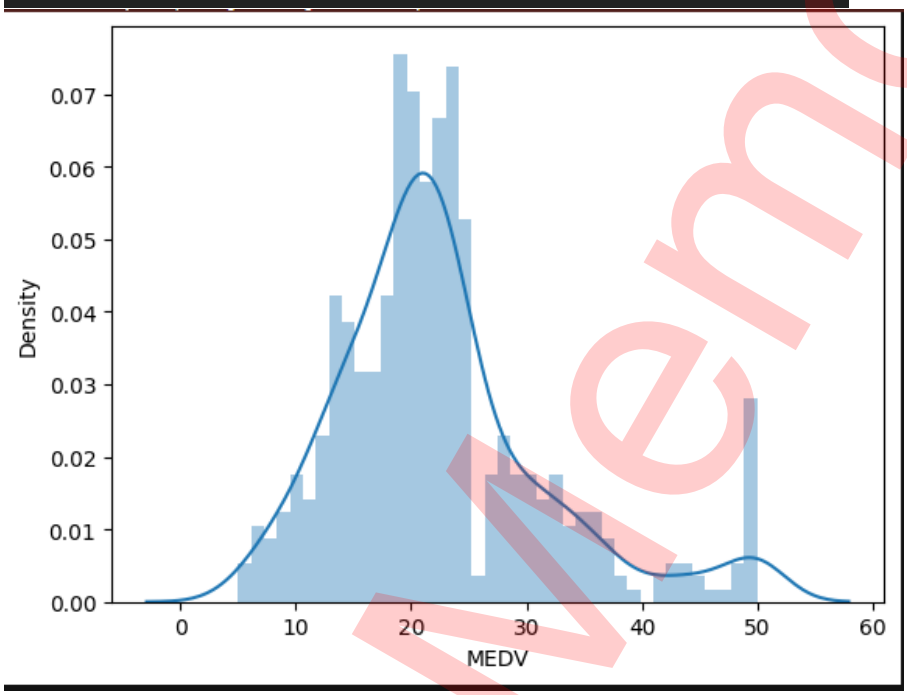
	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	LSTAT	MEDV
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296.0	15.3	4.98	24.0
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242.0	17.8	9.14	21.6
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242.0	17.8	4.03	34.7
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222.0	18.7	2.94	33.4
4	0.06905	0.0	2.18	0	0.458	7.147	54.2	6.0622	3	222.0	18.7	5.33	36.2
...	...	...	...	...	...	...	...	...	...	...	...	...	...
501	0.06263	0.0	11.93	0	0.573	6.593	69.1	2.4786	1	273.0	21.0	9.67	22.4
502	0.04527	0.0	11.93	0	0.573	6.120	76.7	2.2875	1	273.0	21.0	9.08	20.6
503	0.06076	0.0	11.93	0	0.573	6.976	91.0	2.1675	1	273.0	21.0	5.64	23.9
504	0.10959	0.0	11.93	0	0.573	6.794	89.3	2.3889	1	273.0	21.0	6.48	22.0
505	0.04741	0.0	11.93	0	0.573	6.030	80.8	2.5050	1	273.0	21.0	7.88	11.9

506 rows × 13 columns

```
# 1 mark
data.describe()
```

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	LSTAT	MEDV
count	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000
mean	3.613524	11.363636	11.136779	0.069170	0.554695	6.284634	67.982016	3.795043	9.549407	408.237154	18.455534	12.653063	22.532806
std	8.601545	23.322453	6.860353	0.253994	0.115878	0.702617	28.532006	2.105710	8.707259	168.537116	2.164946	7.141062	9.197104
min	0.006320	0.000000	0.460000	0.000000	0.385000	3.561000	0.000000	1.129600	1.000000	187.000000	12.600000	1.730000	5.000000
25%	0.082045	0.000000	5.190000	0.000000	0.449000	5.885500	43.475000	2.100175	4.000000	279.000000	17.400000	6.950000	17.025000
50%	0.256510	0.000000	9.690000	0.000000	0.538000	6.208500	76.800000	3.207450	5.000000	330.000000	19.050000	11.360000	21.200000
75%	3.677083	12.500000	18.100000	0.000000	0.624000	6.623500	93.875000	5.188425	24.000000	666.000000	20.200000	16.955000	25.000000
max	88.976200	100.000000	27.740000	1.000000	0.871000	8.780000	100.000000	12.126500	24.000000	711.000000	22.000000	37.970000	50.000000

```
# 3 marks in Total
#   1 mark for histogram displaying property price
#   1 mark for 40 bins
#   1 mark for displaying the normality distribution curve
plt.figure()
sns.distplot(data['MEDV'], bins=40)
plt.show()
```

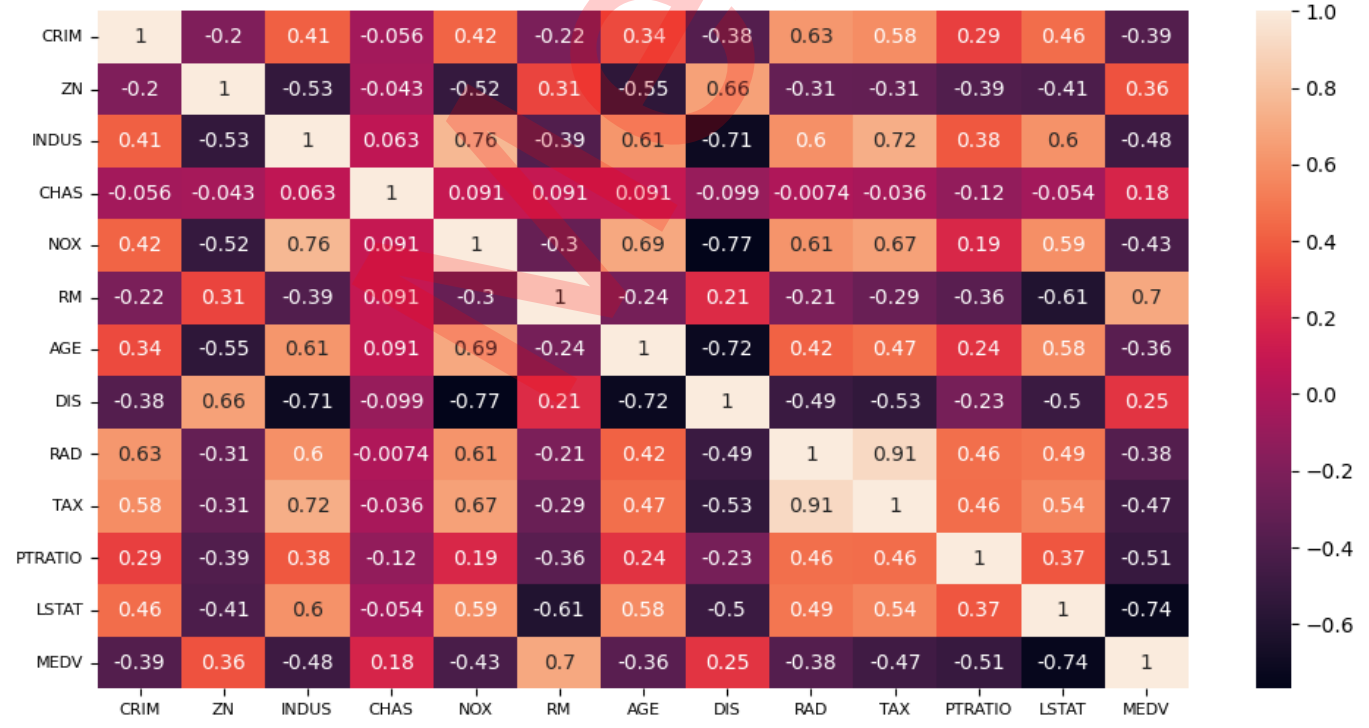


Correlation

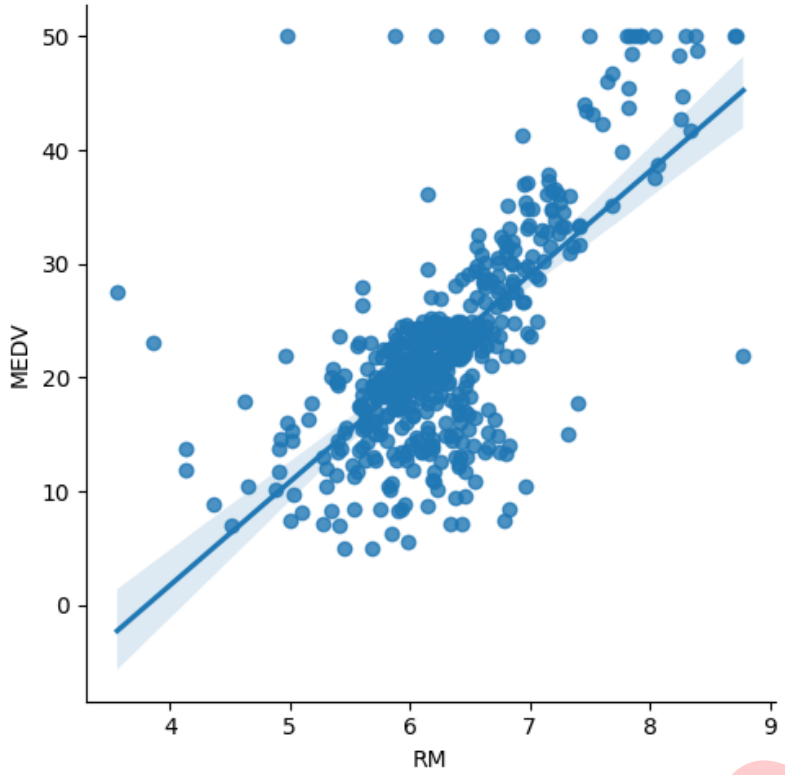
```
# 1 mark
data.corr()
```

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	LSTAT	MEDV
CRIM	1.000000	-0.200469	0.406583	-0.055892	0.420972	-0.219247	0.336388	-0.379670	0.625505	0.582764	0.289946	0.455621	-0.388305
ZN	-0.200469	1.000000	-0.533828	-0.042697	-0.516604	0.311991	-0.551745	0.664408	-0.311948	-0.314563	-0.391679	-0.412995	0.360445
INDUS	0.406583	-0.533828	1.000000	0.062938	0.763651	-0.391676	0.614987	-0.708027	0.595129	0.720760	0.383248	0.603800	-0.483725
CHAS	-0.055892	-0.042697	0.062938	1.000000	0.091203	0.091251	0.091026	-0.099176	-0.007368	-0.035587	-0.121515	-0.053929	0.175260
NOX	0.420972	-0.516604	0.763651	0.091203	1.000000	-0.302188	0.691167	-0.769230	0.611441	0.668023	0.188933	0.590879	-0.427321
RM	-0.219247	0.311991	-0.391676	0.091251	-0.302188	1.000000	-0.239548	0.205246	-0.209847	-0.292048	-0.355501	-0.613808	0.695360
AGE	0.336388	-0.551745	0.614987	0.091026	0.691167	-0.239548	1.000000	-0.718843	0.415344	0.467811	0.241226	0.576959	-0.355519
DIS	-0.379670	0.664408	-0.708027	-0.099176	-0.769230	0.205246	-0.718843	1.000000	-0.494588	-0.534432	-0.232471	-0.496996	0.249929
RAD	0.625505	-0.311948	0.595129	-0.007368	0.611441	-0.209847	0.415344	-0.494588	1.000000	0.910228	0.464741	0.488676	-0.381626
TAX	0.582764	-0.314563	0.720760	-0.035587	0.668023	-0.292048	0.467811	-0.534432	0.910228	1.000000	0.460853	0.543993	-0.468536
PTRATIO	0.289946	-0.391679	0.383248	-0.121515	0.188933	-0.355501	0.241226	-0.232471	0.464741	0.460853	1.000000	0.374044	-0.507787
LSTAT	0.455621	-0.412995	0.603800	-0.053929	0.590879	-0.613808	0.576959	-0.496996	0.488676	0.543993	0.374044	1.000000	-0.737663
MEDV	-0.388305	0.360445	-0.483725	0.175260	-0.427321	0.695360	-0.355519	0.249929	-0.381626	-0.468536	-0.507787	-0.737663	1.000000

```
# 6 marks in Total
#   2 marks for figure with width of 12 and height of 6
#   2 marks for the heatmap correlation figures displayed
#   1 mark for x axis labels with size of 8
#   1 mark for y axis labels with size of 8
plt.figure(figsize=(12, 6))
sns.heatmap(data.corr(), annot=True)
plt.xticks(fontsize=8)
plt.yticks(fontsize=8)
plt.show()
```




```
# 1 mark
sns.lmplot(x='RM', y='MEDV', data=data)
plt.show()
```



Training & Test Dataset Split ¶

```
# 5 marks in Total
#   1 mark for the target variable (MEDV)
#   1 mark for the features variable
#   3 marks to create the 80% train, 20% test split, with shuffling enabled
property_prices = data['MEDV']
features = data.drop('MEDV', axis=1)

X_train, X_test, y_train, y_test = train_test_split(features, property_prices,
                                                    test_size=0.2, random_state=10)
```

Multivariable Regression

```
# 5 marks in Total
#   1 mark for fitting the relevant data to the regression model
#   1 mark for displaying the training data R-squared
#   1 mark for displaying the test data R-squared
#   1 mark for displaying the regression intercept
#   1 mark for displaying the regression coefficient per feature

regr = LinearRegression()
regr.fit(X_train, y_train)

print('Training data r-squared:', regr.score(X_train, y_train))
print('Test data r-squared:', regr.score(X_test, y_test))

print('Intercept', regr.intercept_)
pd.DataFrame(data=regr.coef_, index=X_train.columns, columns=['coef'])
```

```
Training data r-squared: 0.73850632682846
Test data r-squared: 0.6814654355654757
Intercept 43.14726594586092
```

	coef
CRIM	-0.142638
ZN	0.064702
INDUS	-0.023881
CHAS	2.249720
NOX	-17.426335
RM	2.881629
AGE	0.017047
DIS	-1.535008
RAD	0.280364
TAX	-0.012449
PTRATIO	-0.789768
LSTAT	-0.607238

Data Transformations

```
# 1 mark
data['MEDV'].skew()
```

```
1.1080984082549072
```

```
# 2 marks in Total
#   1 mark for log property price
#   1 mark for checking the skew of the data
y_log = np.log(data['MEDV'])
y_log.skew()
```

```
-0.33032129530987864
```

```
# 3 marks in Total
#   1 mark for histogram displaying property price
#   1 mark for displaying the log transformation normality distribution curve
#   1 mark for a title: 'Property price with log transformation'

sns.distplot(y_log)
plt.title(f'Property price with log transformation')
plt.show()
```

Regression using Log Prices

```
# 5 marks in Total
#   1 mark for fitting the relevant data to the log transformation regression model
#   1 mark for displaying the log transformation training data R-squared
#   1 mark for displaying the log transformation test data R-squared
#   1 mark for displaying the log transformation regression intercept
#   1 mark for displaying the log transformation regression coefficient per feature

property_prices = np.log(data['MEDV'])
features = data.drop('MEDV', axis=1)

X_train, X_test, y_train, y_test = train_test_split(features, property_prices,
                                                    test_size=0.2, random_state=10)

regr = LinearRegression()
regr.fit(X_train, y_train)

print('Training data r-squared:', regr.score(X_train, y_train))
print('Test data r-squared:', regr.score(X_test, y_test))

print('Intercept', regr.intercept_)
pd.DataFrame(data=regr.coef_, index=X_train.columns, columns=['coef'])
```

```
Training data r-squared: 0.7813696598412383
Test data r-squared: 0.761416216442926
Intercept 4.356977075487654
```

	coef
CRIM	-0.011315
ZN	0.001626
INDUS	0.001301
CHAS	0.093786
NOX	-0.744787
RM	0.064057
AGE	0.000619
DIS	-0.050783
RAD	0.013421
TAX	-0.000660
PTRATIO	-0.033286
LSTAT	-0.032321

SECTION B TOTAL **35**