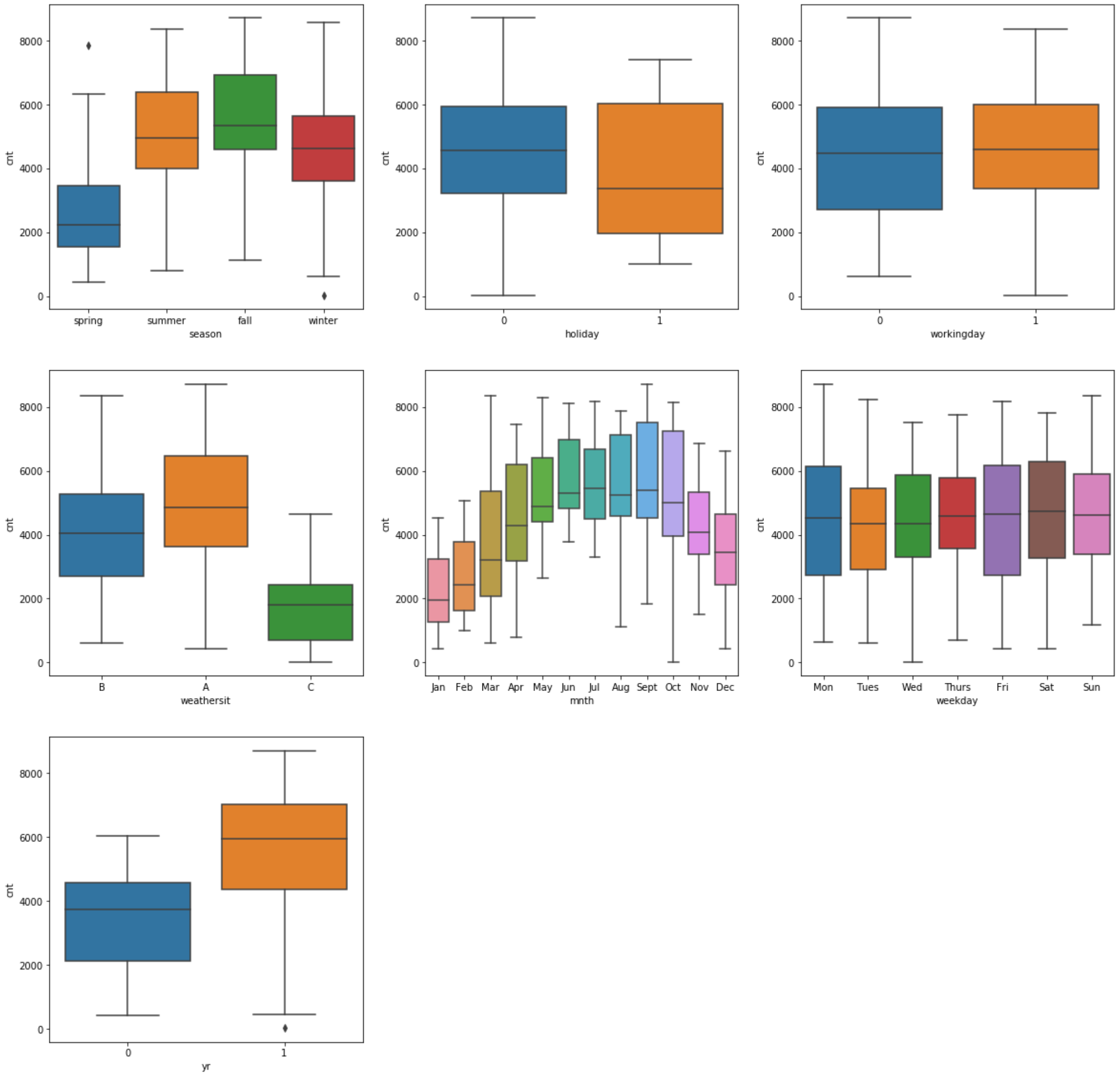
Assignment-based Subjective Questions And Answers.

1. **From your analysis of the categorical variables from the dataset, what could you infer about their effect on the dependent variable?(3 marks)**

   The effect of categorical variables on the dependent variable (“**cnt**”) can be seen below:



   a. “Fall” season affects the dependent variable the most, followed by “Summer” and “Winter”. “Spring” doesn’t have that much impact.
   b. Non-Holiday days have a bit more influence on the dependent variable.
   c. “Workingday” variable has no visible impact.
   d. Pleasant weather affects the dependent variable more positively. Extreme unpleasant weather is seen to have a strong negative correlation with the dependent variable.
   e. “month” variable shows a similar trend asin “season” variable. “Jul” and “Sept” have a high average positive impact on the dependent variable.

f. “Weekday” variable shows no relative impact
g. “2019” / “1” in “yr” variable seems to have a visibly high impact on the dependent variable compared to “2018” / “0”

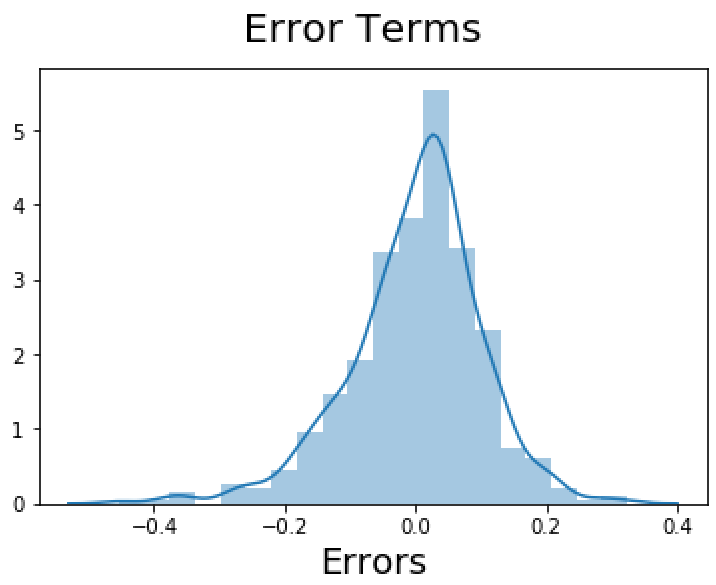
2. **Why is it important to use drop_first=True during dummy variable creation? (2 mark)**

   “drop_first=True” argument of dummy variable creation is to reduce the number of dummy variable columns by one. The logic behind is that : if the value for a sample is “0” for every dummy variable column then it is “1” for the dummy variable column which was omitted by using “drop_first=True”. This allows to reduce the number of columns without any loss of information.

3. **Looking at the pair-plot among the numerical variables, which one has the highest correlation with the target variable?(1 mark)**

   “registered” has the highest correlation with the target variable “cnt” in the pair-plot for only numerical variables. This can also inferred directly since the value in “cnt” is equal to “registered” plus “casual” variable.

4. **How did you validate the assumptions of Linear Regression after building the model on the training set? (3 marks)**



Residual analysis shows a normal distribution which is centered around zero. This is one of the most important checks of Linear Regression.

5. **Based on the final model, which are the top 3 features contributing significantly towards explaining the demand of the shared bikes? (2 marks)**

Top three features are “Weathersit_C”, “mnth_Jul” and “season_Spring”. These three have least value of VIF , which was calculated at the end of feature selection. All three have high influence on the target variable.

General Subjective Questions

1. **Explain the linear regression algorithm in detail. (4 marks)**

Linear Regression is a machine learning algorithm based on supervised learning. It performs a regression task. Regression models a target prediction value based on independent variables. It is mostly used for finding out the relationship between variables and forecasting. Different regression models differ based on – the kind of relationship between dependent and independent variables, they are considering, and the number of independent variables being used.

Linear regression performs the task to predict a dependent variable value (y) based on a given independent variable (x). So, this regression technique finds out a linear relationship between x (input) and y(output). Hence, the name is Linear Regression.

In the figure above, X (input) is the work experience and Y (output) is the salary of a person. The regression line is the best fit line for our model.

Hypothesis function for Linear Regression:

Y = θ 1 + θ 2.x

While training the model we are given:

x: input training data (univariate – one input variable(parameter))

y: labels to data (supervised learning)

When training the model – it fits the best line to predict the value of y for a given value of x. The model gets the best regression fit line by finding the best θ 1 and θ 2 values.

θ 1: intercept

θ 2: coefficient of x

Once we find the best θ 1 and θ 2 values, we get the best fit line. So when we are finally using our model for prediction, it will predict the value of y for the input value of x.

How to update θ 1 and θ 2 values to get the best fit line ?

Cost Function (J):

By achieving the best-fit regression line, the model aims to predict y value such that the error difference between predicted value and true value is minimum. So, it is very important to update the θ 1 and θ 2 values, to reach the best value that minimize the error between predicted y value (pred) and true y value (y).

$$minimize\frac{1}{n}\sum_{i=1}^{n}(pred_i - y_i)^2$$

$$J = \frac{1}{n}\sum_{i=1}^{n}(pred_i - y_i)^2$$

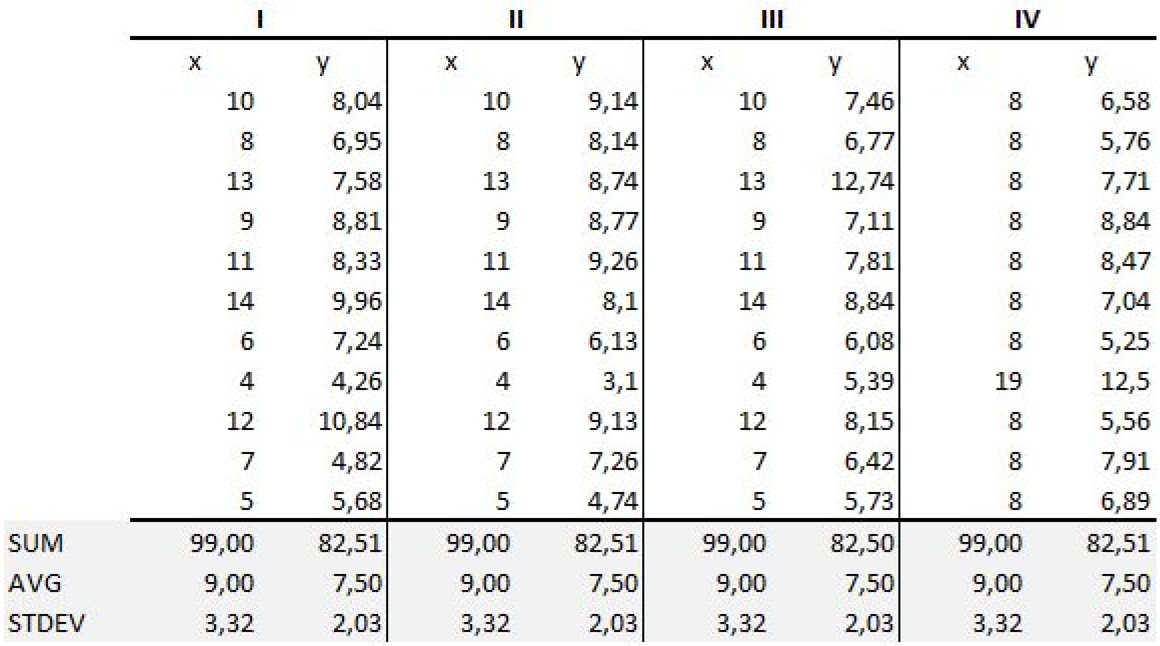
Cost function(J) of Linear Regression is the Root Mean Squared Error (RMSE) between predicted y value (pred) and true y value (y).

Gradient Descent:

To update θ 1 and θ 2 values in order to reduce Cost function (minimizing RMSE value) and achieving the best fit line the model uses Gradient Descent. The idea is to start with random θ 1 and θ 2 values and then iteratively updating the values, reaching minimum cost.

2. **Explain the Anscombe's quartet in detail. (3 marks)**

Anscombe's Quartet was developed by statistician Francis Anscombe. It comprises four datasets, each containing eleven (x,y) pairs. The essential thing to note about these datasets is that they share the same descriptive statistics. But things change completely, and I must emphasize COMPLETELY, when they are graphed. Each graph tells a different story irrespective of their similar summary statistics.

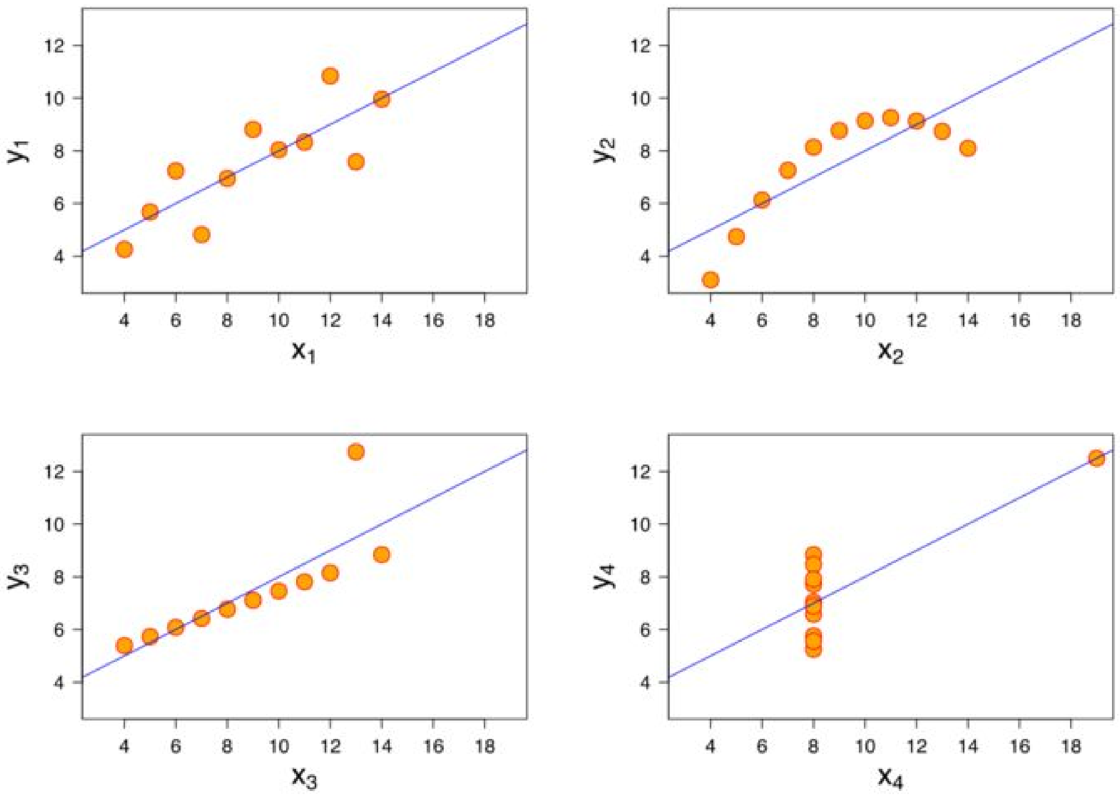


	I		II		III		IV	
	x	y	x	y	x	y	x	y
	10	8,04	10	9,14	10	7,46	8	6,58
	8	6,95	8	8,14	8	6,77	8	5,76
	13	7,58	13	8,74	13	12,74	8	7,71
	9	8,81	9	8,77	9	7,11	8	8,84
	11	8,33	11	9,26	11	7,81	8	8,47
	14	9,96	14	8,1	14	8,84	8	7,04
	6	7,24	6	6,13	6	6,08	8	5,25
	4	4,26	4	3,1	4	5,39	19	12,5
	12	10,84	12	9,13	12	8,15	8	5,56
	7	4,82	7	7,26	7	6,42	8	7,91
	5	5,68	5	4,74	5	5,73	8	6,89
SUM	99,00	82,51	99,00	82,51	99,00	82,50	99,00	82,51
AVG	9,00	7,50	9,00	7,50	9,00	7,50	9,00	7,50
STDEV	3,32	2,03	3,32	2,03	3,32	2,03	3,32	2,03

The summary statistics show that the means and the variances were identical for x and y across the groups:

- Mean of x is 9 and mean of y is 7.50 for each dataset.
- Similarly, the variance of x is 11 and variance of y is 4.13 for each dataset
- The correlation coefficient (how strong a relationship is between two variables) between x and y is 0.816 for each dataset.

When we plot these four datasets on an x/y coordinate plane, we can observe that they show the same regression lines as well but each dataset is telling a different story:



- Dataset I appear to have clean and well-fitting linear models.
- Dataset II is not distributed normally.
- In Dataset III the distribution is linear, but the calculated regression is thrown off by an outlier.
- Dataset IV shows that one outlier is enough to produce a high correlation coefficient.

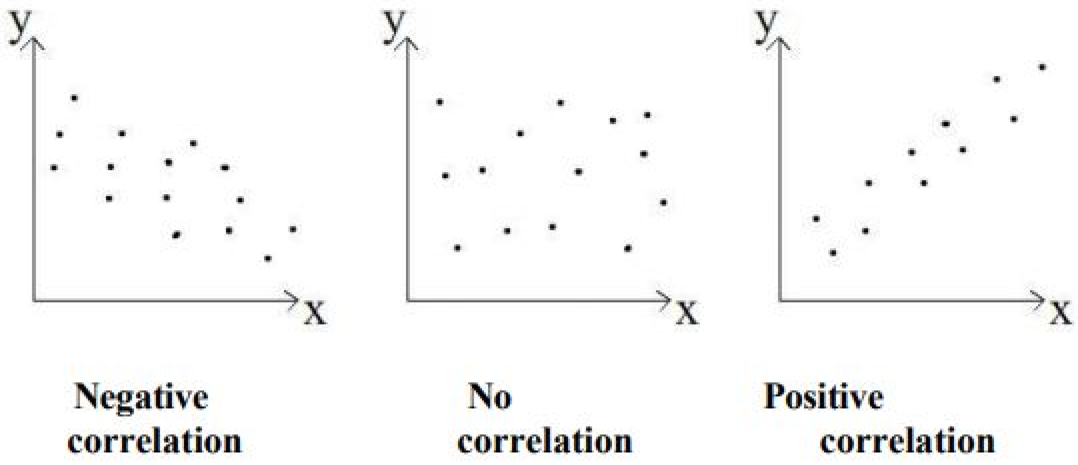
This quartet emphasizes the importance of visualization in Data Analysis. Looking at the data reveals a lot of the structure and a clear picture of the dataset.

3. **What is Pearson’s R?(3 marks)**

Often several quantitative variables are measured on each member of a sample. If we consider a pair of such variables, it is frequently of interest to establish if there is a relationship between the two; i.e. to see if they are correlated.
We can categories the type of correlation by considering as one variable increases what happens to the other variable:

- Positive correlation – the other variable has a tendency to also increase;
- Negative correlation – the other variable has a tendency to decrease;
- No correlation – the other variable does not tend to either increase or decrease.

The starting point of any such analysis should thus be the construction and subsequent examination of a scatterplot. Examples of negative, no and positive correlation are as follows.



Correlation coefficient

Pearson's correlation coefficient is a statistical measure of the strength of a linear relationship between paired data. In a sample it is denoted by r and is by design constrained as follows

Furthermore:

- Positive values denote positive linear correlation;
- Negative values denote negative linear correlation;
- A value of 0 denotes no linear correlation;
- The closer the value is to 1 or –1, the stronger the linear correlation.

4. **What is scaling? Why is scaling performed? What is the difference between normalized scaling and standardized scaling? (3 marks)**

What is scaling?

Scaling is a technique to standardize the independent features present in the data in a fixed range. It is performed during the data pre-processing to handle highly varying magnitudes or values or units. If feature scaling is not done, then a machine learning algorithm tends to weigh greater values, higher and consider smaller values as the lower values, regardless of the unit of the values.

Why is scaling performed?

It basically helps to normalise the data within a particular range. Sometimes, it also helps in speeding up the calculations in an algorithm.

Real world dataset contains features that highly vary in magnitudes, units, and range. Normalisation should be performed when the scale of a feature is irrelevant or misleading and not should Normalise when the scale is meaningful.

The algorithms which use Euclidean Distance measure are sensitive to Magnitudes. Here feature scaling helps to weigh all the features equally.

Formally, If a feature in the dataset is big in scale compared to others then in algorithms where Euclidean distance is measured this big scaled feature becomes dominating and needs to be normalized.

What is the difference between normalized scaling and standardized scaling?

The terms normalization and standardization are sometimes used interchangeably, but they usually refer to different things. Normalization usually means to scale a variable to have a values between 0 and 1, while standardization transforms data to have a mean of zero and a standard deviation of 1. This standardization is called a z-score, and data points can be standardized with the following formula:

$$z_i = \frac{x_i - \bar{x}}{s}$$

A z-score standardizes variables.

Where:

xi is a data point (x1, x2…xn).

x¯ is the sample mean.

s is the sample standard deviation

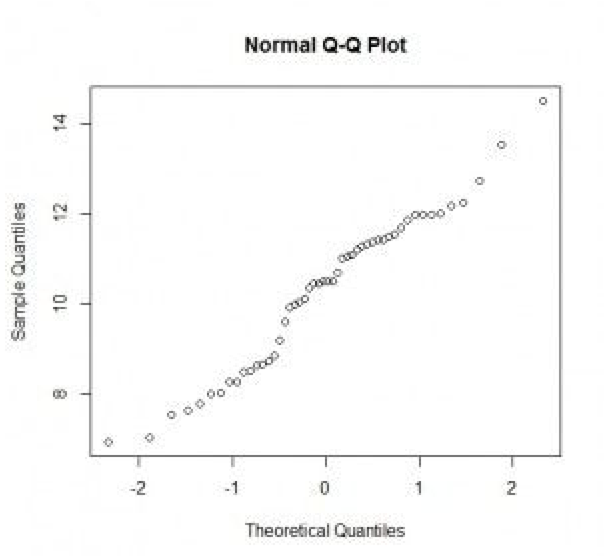
5. You might have observed that sometimes the value of VIF is infinite. Why does this happen? (3 marks)

If VIF value is infinite then that means there is perfect collinearity. Data is having completely redundant variables.
VIF = 1/(1-R2) = Inf means R2 is 1 that indicates that feature is related to otger feature.

6. What is a Q-Q plot? Explain the use and importance of a Q-Q plot in linear regression. (3 marks)

The Q-Q plot, or quantile-quantile plot, is a graphical tool to help us assess if a set of data plausibly came from some theoretical distribution such as a Normal or exponential. For example, if we run a statistical analysis that assumes our dependent variable is Normally distributed, we can use a Normal Q-Q plot to check that assumption. It’s just a visual check, not an air-tight proof, so it is somewhat subjective. But it allows us to see at-a-glance if our assumption is plausible, and if not, how the assumption is violated and what data points contribute to the violation.

A Q-Q plot is a scatterplot created by plotting two sets of quantiles against one another. If both sets of quantiles came from the same distribution, we should see the points forming a line that's roughly straight. Here's an example of a Normal Q-Q plot when both sets of quantiles truly come from Normal distributions.



Explain the use and importance of a Q-Q plot in linear regression.

Quantile-Quantile (Q-Q) plot, is a graphical tool to help us assess if a set of data plausibly came from some theoretical distribution such as a Normal, exponential or Uniform distribution. Also, it helps to determine if two data sets come from populations with a common distribution.

This helps in a **scenario of linear regression** when we have training and test data set received separately and then we can confirm using Q-Q plot that both the data sets are from populations with same distributions.

Few advantages:

a) It can be used with sample sizes also

b) Many distributional aspects like shifts in location, shifts in scale, changes in symmetry, and the presence of outliers can all be detected from this plot.

It is used to check following scenarios:

If two data sets —

i. come from populations with a common distribution

ii. have common location and scale

iii. have similar distributional shapes

iv. have similar tail behavior

Interpretation:

A q-q plot is a plot of the quantiles of the first data set against the quantiles of the second data set.

Below are the possible interpretations for two data sets.

a) Similar distribution: If all point of quantiles lies on or close to straight line at an angle of 45 degree from x -axis

b) Y-values < X-values: If y-quantiles are lower than the x-quantiles.

c) X-values < Y-values: If x-quantiles are lower than the y-quantiles.

d) Different distribution: If all point of quantiles lies away from the straight line at an angle of 45 degree from x -axis