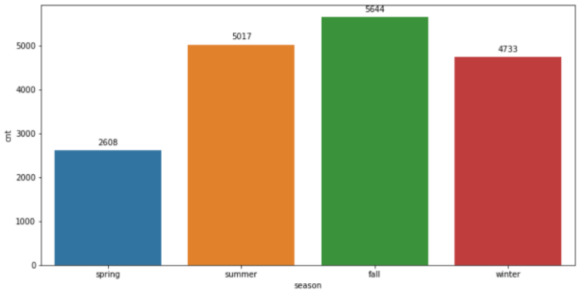
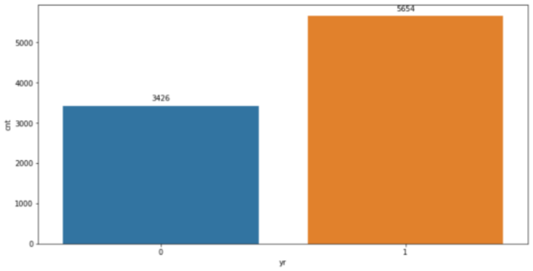
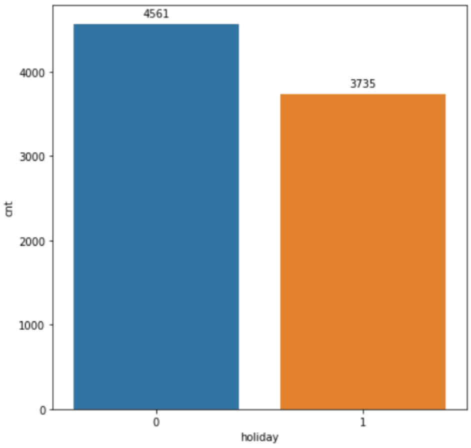
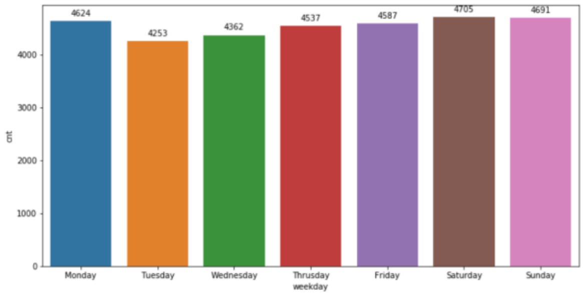
Assignment-based Subjective

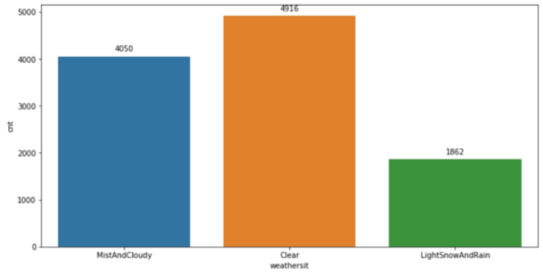
1. From your analysis of the categorical variables from the dataset, what could you infer about their effect on the dependent variable? (3 marks)
   Answer:
   Season, yr, month, weathersit and holiday have a strong effect on the dependent variable
   Weekday and holiday doesn’t have a strong effect on the dependent variable.
   This can be inferred from seeing the barplots for the variable:

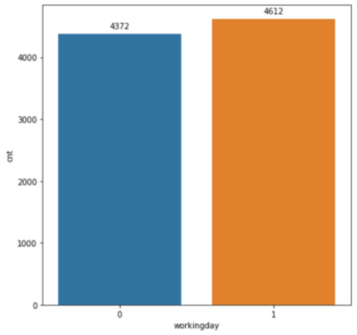


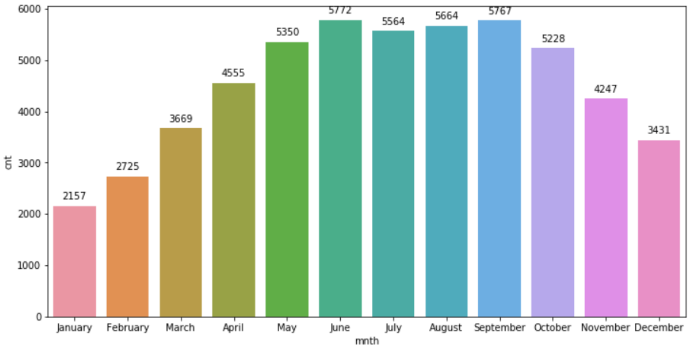












2. Why is it important to use **drop_first=True** during dummy variable creation? (2 mark)
Answer:
We use **drop_first=True** during dummy variable creation because the extra column is not needed and is redundant. Keeping it in the dataset will increase the size, might increase the complexity and might increase correlation.
Information needed from the column can be obtained even after dropping the first column, it can be verified from the below example from the assignment.
We have four values in Season column, Spring, Summer, Fall and Winter
On converting it to dummy variable:

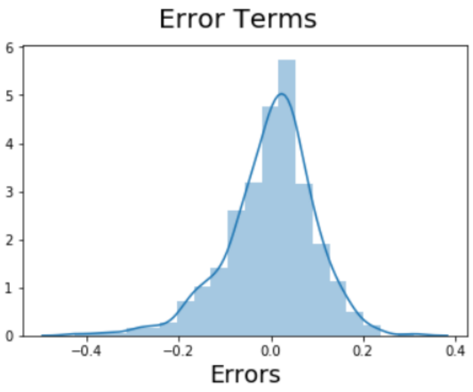
	Keeping first Column					**Removing First Column**		
Season	**Spring**	**Summer**	**Fall**	**Winter**		**Summer**	**Fall**	**Winter**
Spring	1	0	0	0		0	0	0
Summer	0	1	0	0		1	0	0
Fall	0	0	1			0	1	0
Winter	0	0	0	1		0	0	1

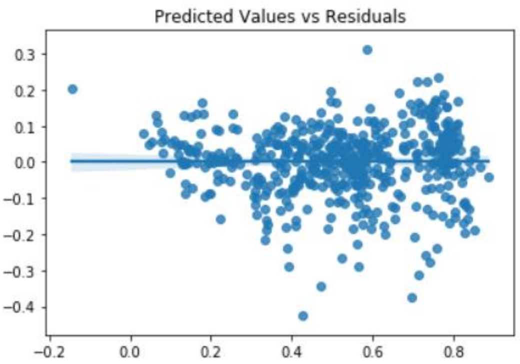
The season column is converted to four columns when first column is not dropped.
The season column is converted to three columns when first column is dropped

Checking for the rows in season column with the columns when first column is dropped
Spring is marked as 0 0 0
Summer as 1 0 0, fall as 0 1 0 and winter as 0 0 1
When all the three columns have 0 value here, it is spring. Hence, the first column is redundant.

3. Looking at the pair-plot among the numerical variables, which one has the highest correlation with the target variable? (1 mark)
Answer:
Temp and atemp have the highest correlation with the target variable

4. How did you validate the assumptions of Linear Regression after building the model on the training set? (3 marks)
Answer:
- Residual errors follow a normal distribution
- Mean for the error term is 0
- Variance of Errors doesn't follow any trends





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

   Answer:

   Top three feature contributing significantly to demand of shared bike are:

yr	0.2383
temp	0.3813
LightSnowAndRain	-0.2469 (weathersit – has a negative effect on demand on bike)

General Subjective

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

   Answer:

   Linear regression is a method of finding the best straight line fitting the given data. It tries to find the best linear relationship between the independent variable and the dependent variable. The simplest form of linear regression is single linear regression in which we use one dependent variable and one independent variable. It is represented as below:

$$Y= bx + C$$

   Y is the estimated dependent variable
   b is the regression coefficient
   C is constant
   x is the independent variable
   The above equation tries to predict the value of Y depending upon the value of x. Linear regression is used to determine the value of b and C in this case, how does a unit change in X effect Y and what will be the value of Y if X is zero.
   For Multiple linear regression, the equation is updated as

$$Y = b1x1 + b2x2 + b3x3\ldots\ldots + C$$

   Where b1, b2 are coefficient of x1,x2… and so on
   In multiple linear regression, we have multiple independent variable and we try to find how change in one independent variable effects the dependent variable.

   For a linear regression following assumptions are made:

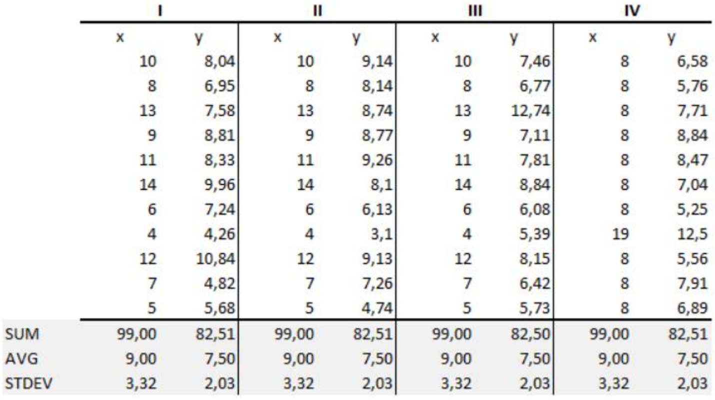
   1. There is linear relation between dependent and independent variables
   2. The error terms are normally distributed
   3. Mean for error term is 0
   4. It is assumed the residual terms have same (but unknown) variance
   5. Residual terms are independent of each other

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

   Answer:

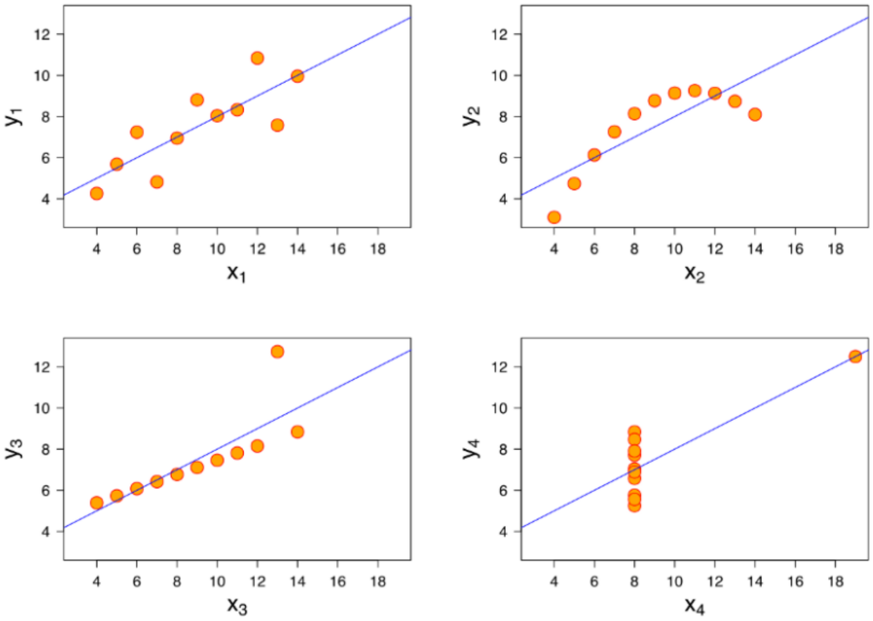
   Anscombe’s quartet developed by a statistician Francis Anscombe highlights the importance of visually analysing the data. He created four datasets with nearly identical statistics but appear completely different when graphed. The idea was to stress the importance of visual analysis and counter the impression "numerical calculations are exact, but graphs are rough."

   Looking at the below table, we can observe, sum, average and standard deviation of all the four dataset are almost exactly same.



	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

Quartet's Summary Stats



Graph and table courtesy: [Medium article]()
The same dataset has been plotted above and the graph of all four are completely different from each other.

3. What is Pearson's R? (3 marks)
   Answer:
   Pearson's R or Pearson product-moment correlation coefficient measures linear correlation between two variables X and Y. It is a measure of strength of the relation between two variables and their association with each other and explains the effect on one variable when other variable changes.
   Its value ranges from +1 to -1, +1 being total positive linear correlation, 0 meaning no linear correlation and -1 meaning total negative linear correlation. A positive correlation means that when X increases Y also increases whereas a negative correlation means when X decreases Y also decreases.
   It is represented as ρ for population and r for sample.

$$r = \frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2- (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

N = number of pairs of data
X and Y are the variables.

4. What is scaling? Why is scaling performed? What is the difference between normalized scaling and standardized scaling? (3 marks)
Answer:
Scaling is a method used to normalize/standardize the range or features of the data. Range of data for different variable may vary widely and that is the reason it is suggested to do scaling in the data pre-processing step when using a machine learning algorithm.
When applying a machine learning algorithm, say linear regression, the gradient descent will take iterations to fit the line. If we have two variables whose range vary widely, gradient descent will be able to work it out in lesser number of iteration while will need a larger number of iteration for variable with a larger range. Hence, scaling is applied to bring down the cost function gradient descent.
Normalization is a scaling method in which the values are rescaled in such a way that they end up between 0 and 1. This is also known as Min-Max Scaling.

$$X' = X- X_{min} / X_{max} - X_{min}$$

X_{max} = Maximum value of X
X_{min} = Minimum value of X
Normalization is helpful in cases where data follows a Gaussian distribution. It subsidizes the effect of outliers as it has a bounding range.

Standardization is a method in which we rescale the value to be centred around mean with a unit standard deviation. Mean of the attributes become 0 and the distribution has a unit standard deviation.

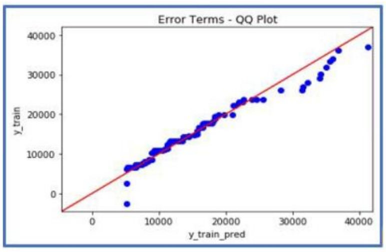
$$X'= X-\mu/\sigma$$

μ is the mean of the feature variable
σ is the standard deviation of the feature variable
Standardization can be helpful for cases where data doesn't follow Gaussian distribution. It doesn't take care of outliers as it doesn't have a bounding range

5. You might have observed that sometimes the value of VIF is infinite. Why does this happen? (3 marks)
Answer:
VIF or variance inflation factor is the measure of correlation between one predictor variable with rest of predictors in the model. It explains how well can a predictor variable be explained with the help of other predictor variables.
An infinite VIF indicates that the variable can be expressed exactly by a linear combination of other variables which show infinite VIF as well. This is due to a perfect correlation between the two variables, because of which we get R2=1 and VIF = 1/1-R2 becomes infinity.
To solve this issue, we need to drop one of the variable from the dataset which is causing multicollinearity.

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

A Q-Q plot of quantile quantile plot is a probability plot to compare two probability distributions by plotting quantile of one against another. It is used to compare properties such as scale, location and skewness is similar or different in the two datasets.
When creating a linear regression model, we assume that the errors are normally distributed with mean 0. Also, that the errors are independent and Homoscedasticity. A QQ plot is plotted between Y_actual and Y_Pred to check and verify the assumptions made for linear regression.


Error Terms - QQ Plot
y_train
y_train_pred