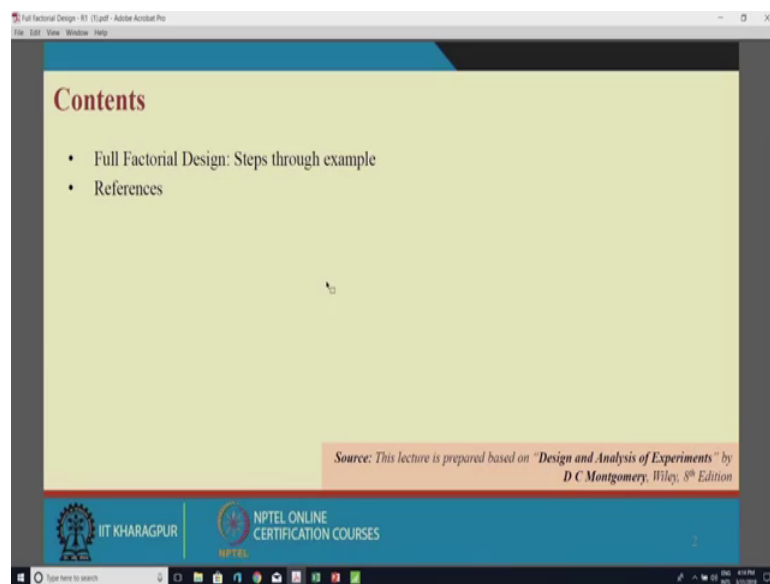


Design and Analysis of Experiments
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Lecture – 58
Factorial Design using MINITAB

Welcome to the lecture number 58. In this section, I will tell about full factorial design using MINITAB that how to use MINITAB for full factorial design.

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So, the content is full factorial design there is some example that I will do in the MINITAB.

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An example

The yield of a chemical process depends on basically two factor: the pressure and the temperature.

Temperature	Pressure	Response
150	200	90.4
150	215	90.2
150	230	90.4
160	200	89.9
160	215	90.1
160	230	90.4
170	200	90.1
170	215	90.8
170	230	90.1

SN	Pressure	Temperature	Response
1	200	150	90.4
2	200	160	90.1
3	200	170	90.5
4	215	150	90.2
5	215	160	90.5
6	215	170	90.8
7	230	150	90.2
8	230	160	89.9
9	230	170	90.4
10	200	150	90.2
11	200	160	90.3
12	200	170	90.7
13	215	150	90.6
14	215	160	90.6
15	215	170	90.9
16	230	150	90.4
17	230	160	90.1
18	230	170	90.3

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So, my cases that the yield of a chemical process depends on basically two factor the pressure and the temperature. So, the data set have taken from the book that sir has given you in various lecture that is design and analysis of experiments Montgomery the data set which we have taken from the chapter number five.

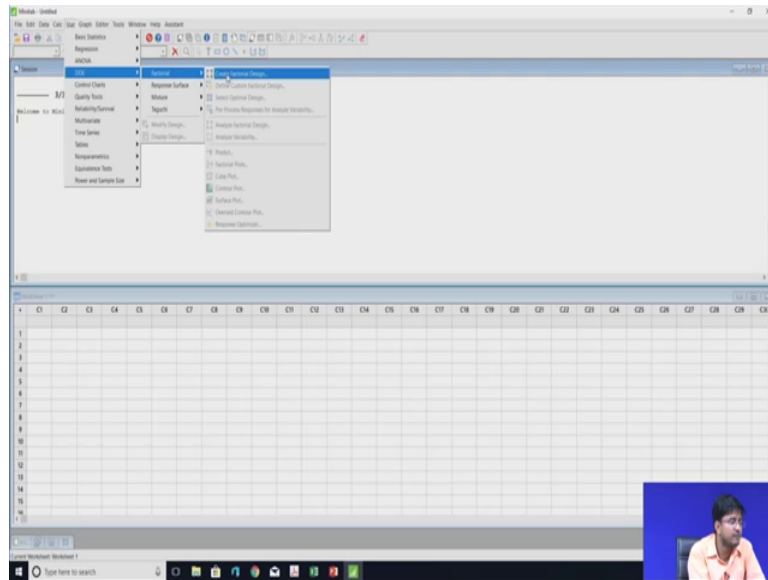
So, this is the temperature, there are three level; 150, 160, 170 and for pressure there also 2 level; 200, 215, 2 230 and rest of all are the yield rate of the, of this chemical process. So, now, I am going to the MINITAB first.

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Temperature	Pressure	Response	A	B	Observation
150	200	90.4	-1	-1	28
150	215	90.2	1	-1	36
150	230	90.4	-1	1	18
160	200	89.9	1	1	31
160	215	90.1	-1	-1	25
160	230	90.4	1	-1	32
170	200	90.1	-1	1	19
170	215	90.8	1	1	30
170	230	90.1	-1	-1	27
		90.3	1	-1	32
		90.7	-1	1	23
		90.6	1	1	29
		90.6			
		90.9			
		90.4			
		90.1			
		90.1			

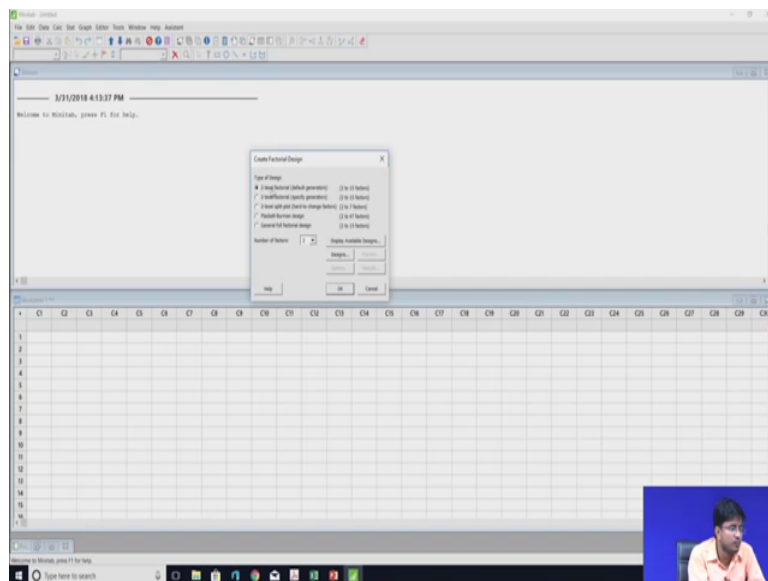
We have to what we have to do? We have to get the data in excel this is the temperature and this is the pressure, temperature is there is 3 level, 150, 160, 170 in pressure 200, 215, 230.

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So, in MINITAB; what we have to do first we have to go to the stat section, then in stat there is doe; from doe will go to the factorial and here it is create factorial design.

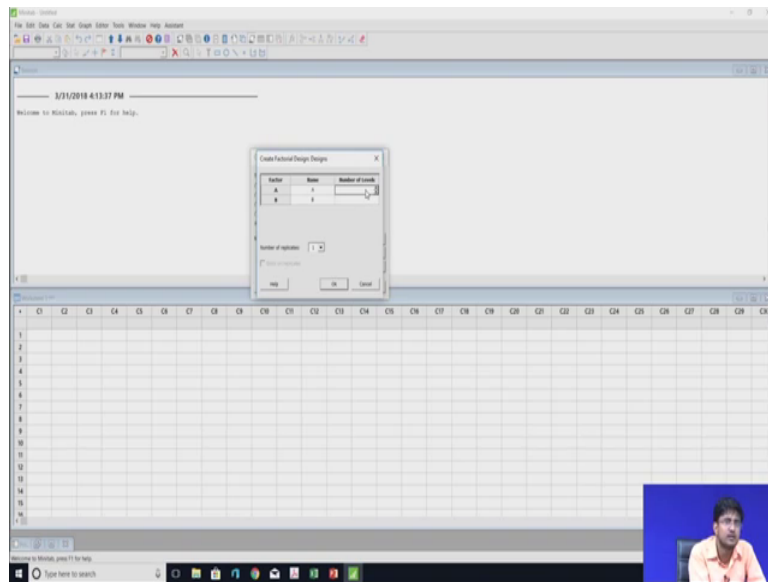
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So, now you can see that there is 2 level factorial design types of design we have to choose. So, there is 2 level factorial design 2 level factorial specify generator, but in this

example we are going through the full factorial design. So, we will take general full factorial design and it is also saying that how many factors are there. So, in this section our factors are 2 A and B temperature and pressure. So, then display available design this is ok, then go to the design it is saying.

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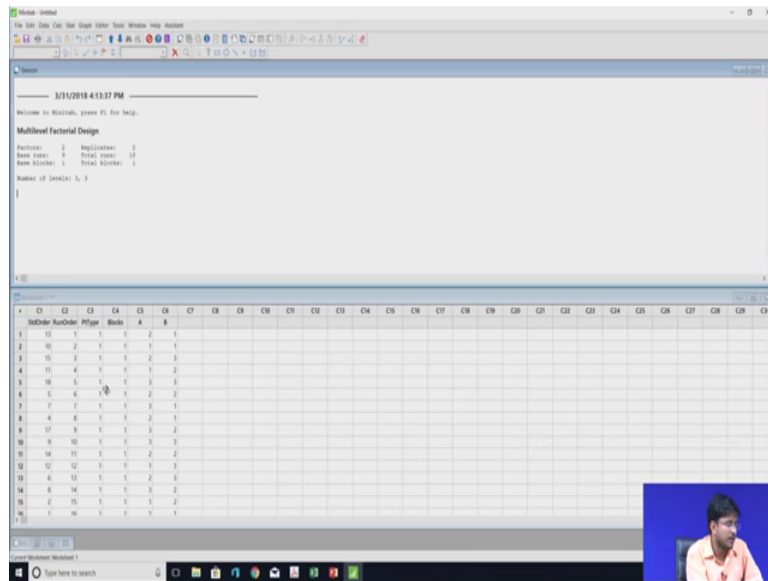


That factor is A; that is pressure and factor is B, that is temperature. So, we have to give that what are the number of levels for pressure there is there are 3 levels. So, we will put it 3 as well as this is very small.

So, we will go to the 3, this is very small and also for B will put 3. So, I am trying to make it larger, there is no option. So, this is this is. So, just I am telling you that for factor A number of levels are 3 for factor b, the factor A is representing temperature, factor B is representing pressure.

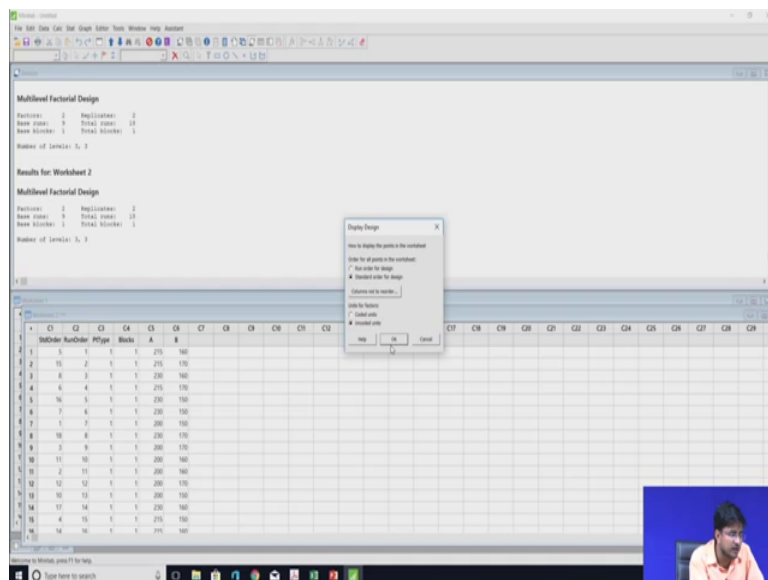
So, also the number of levels are 3 and 3 and here, it is asking the number of replicates. So, in our data number of replicates are 2, this is 90.4 and 90.2. So, number of replicates are 2.

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So, here we will put it 2 number of replicates, then ok, then ok; so, the now the structure of the data that we have to import in MINITAB that is ready. So, after that we have to go again to the stat then doe then we have to go to the display design.

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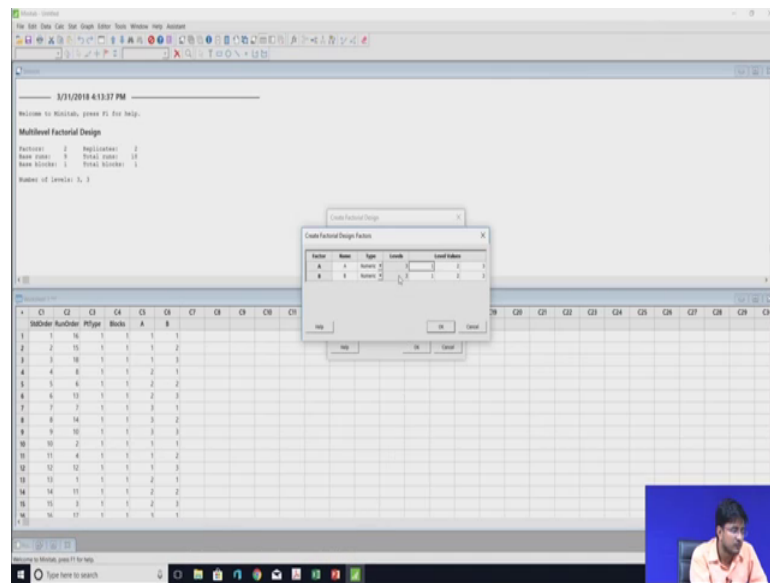


In display design, it is saying that we have to give the data in a standard order that standard. So, we will choose the standard order for design, then we will go to the. So, now, our data set is ready. So, also we have option that in stat in doe factorial create

factorial design in factor, we can change our level that we in the example we know the for temperature our levels are 150, 160, 170.

And for pressure our levels are 200, 215 and 230. So, for A; if we choose A is representing pressure than 200, 215 and 230.

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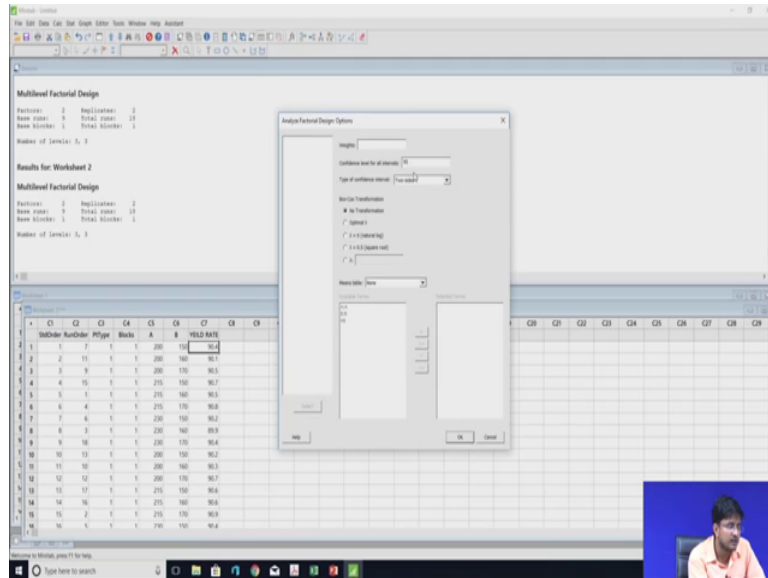
So, it will be 200, then 215, then 230 and if B is representing temperature. So, the level will be 150, 160, 170. So, it will be 150, 230, then 160 and 170, they will go for. So, now, our actual data set is ready at A are the level wise. So, again we have to standard we have to standardize our order.

So, you will go to the doe and then display design and then select standard order for design. So, our data set is now ready. Now, we have to put the yield rate here yield; yield rate. So, in our case, this is our yield rate if we copy all the value. So, now, or yield rate is ready. So, yield rate is already giving that pressure is 200 and temperature is 150, then yield rate will be 90.4.

Again pressure is 200 and temperature is 160, then it will be 90.1, in that manner, we have organised all the data. So, we will just copy from the excel and putting it in the MINITAB. So, now, what data set is full ready for analysing in MINITAB? So, next we will go to the stat doe factorial analyse factorial design here it is asking what are the response. So, yield rate is the response then we will go to the terms that in factorial

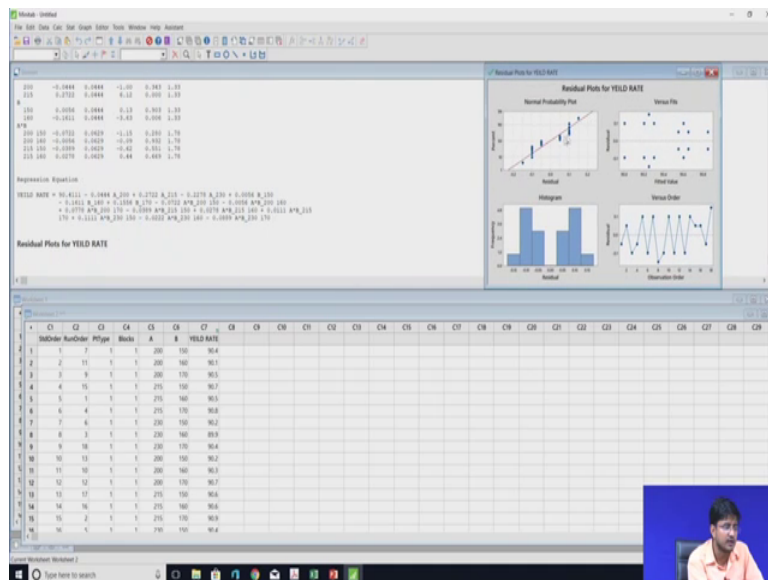
design what the terms you want that is A; that then B, then AB all the things, we want then in option in there is 95 percent confident interval.

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And also the 2 sided, then in graph we will take 4 in 1.

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So, that we can take all the graph here, then we will go to the ok. So, we will get these are graph normal probability plot residuals versus fitted order frequency versus residual, residual versus observation order and the result we have got. So, we extending it.

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Number of Levels: 3, 3

Results for Worksheet 2

Multilevel Factorial Design

Factors: 2 Replications: 2
 Run order: 9 Total runs: 18
 Base number: 1 Total number: 1
 Number of Levels: 3, 3

General Factorial Regression: YIELD RATE versus A, B

Factor Information

Factor	Level	Value
A	1	100, 115, 200
B	1	100, 100, 170

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	8	0.12979	0.16224	27.626	0.000
A	2	0.08039	0.04019	15.00	0.001
B	2	0.04940	0.02470	9.50	0.004
AB	4	0.00000	0.00000	0.00	0.999
Error	9	1.29779	0.14420		
Total	17	1.29779			

Model Summary

R	R-sq	R-sq(Adj)	R-sq(Pred)
0.32333	87.67%	76.71%	55.65%

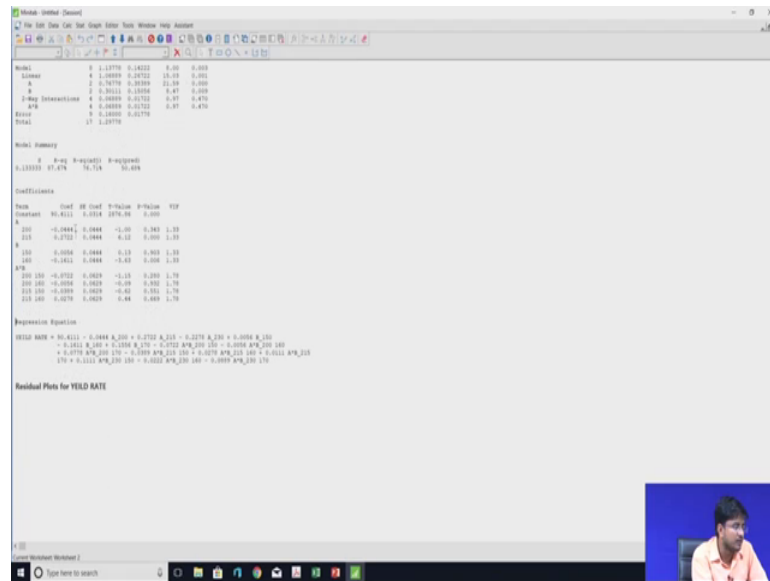
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	94.4111	0.2518	2376.00	0.000	
A					
100	-0.0000	0.0000	-0.00	0.999	1.33
115	0.1732	0.0444	4.12	0.000	1.33
200	0.0000	0.0000	0.00	0.999	1.33
B					
100	-0.2012	0.0444	-4.53	0.000	1.33
170	0.0000	0.0000	0.00	0.999	1.33
200	-0.0732	0.0444	-1.65	0.100	1.70
AB					
100 100	-0.0000	0.0020	-0.00	0.992	1.70
115 100	-0.0000	0.0020	-0.00	0.992	1.70
200 100	-0.0000	0.0020	-0.00	0.992	1.70
100 170	0.0000	0.0020	0.00	0.999	1.70
115 170	0.0000	0.0020	0.00	0.999	1.70
200 170	0.0000	0.0020	0.00	0.999	1.70

So, these are the result that this is the analysis ANOVA table for this experiment, this is actually very small. So, this is for the model, the degree of freedom is 8 and adjacent faces is given and for A 1 from A that for A that is temperature the degree of freedom is 2 the level is 3 that is your degree of freedom is 2 it is SS square is their there.

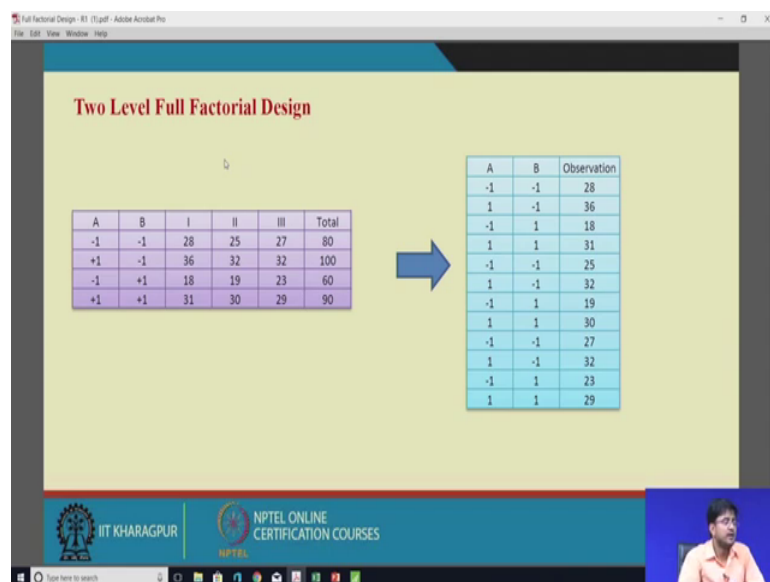
Then the MS square is there, then from there, we will get the F value also B all the things are there, then for AB degree of freedom, SS square, MS square and F value of there also, we will get the error MS value and accordingly, we will calculate all the F value. So, we can tell that whether the factor A is affecting the yield rate, B is affecting the yield rate or their interaction is affecting the yield rate or not.

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And also all the others value that term constant effect all the things; we AB effect and also we will get the regression equation from MINITAB. So, this is full factorial design now also we know that in factorial design.

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I am directly going to the when there are 2 level full factorial design, suppose the last example; we have seen in there are 3 level, but in 2 to the power k design, there is 2 level, this example is basically 2 to the 4 design that for A, there is plus minus 1 and plus 1 for B, there is also minus 1 and plus 1 and also this data, we have taken this

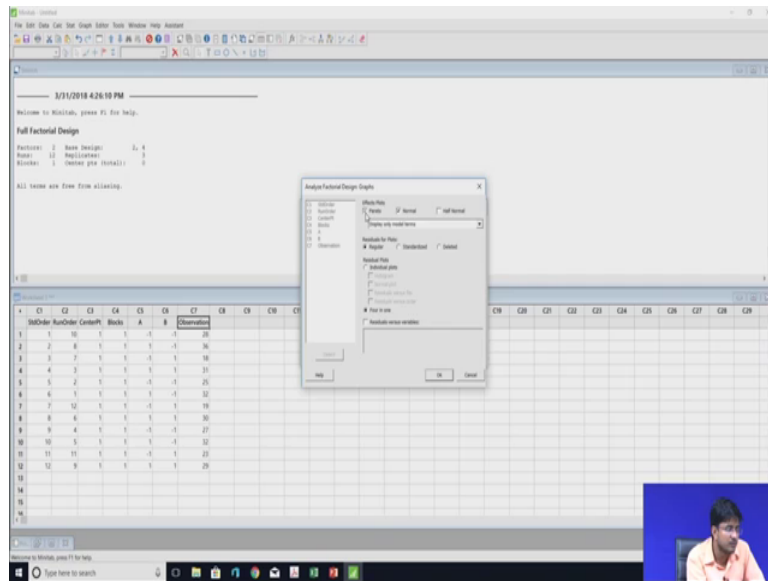
example, actually we have taken from the Douglas and Montgomery design and analysis of experiment book. So, there are 3 replicates 1, 2 and 3 and the total 28 plus 25 plus 27 that is 80. So, in this manner, we will design our data set like this that we will put A minus 1 plus 1, then minus 1 plus 1 for B minus 1 minus 1 plus 1 plus 1.

And then we will copy all the value here and we will paste it observation then again the same thing we will do for this the same thing we will do for this. So, in MINITAB; now, opening new project in MINITAB; so, now, again I am going to stat, then doe then factorial then create factorial design. So, here we are basically talking about 2 level factory design.

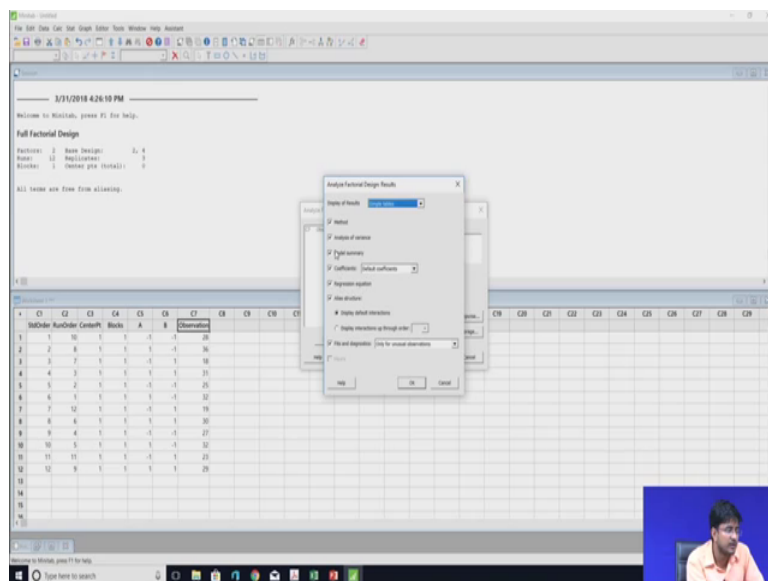
So, the first option we will take that 2 level factorial design here also number of factors are 2, then we will going to design in design it is saying that number of replicate for corner point how many replicates we have we have here 3 replicate then. So, now, our structure of the importing data in MINITAB is ready, now again we will go to the stat, then doe, then display design and we will tick standard order for design then ok. So, now, what data set is ready and we have to just copy the observation value from excel and put it in the MINITAB.

So, now our full data set is ready we will just go to the stat doe factorial and analyse factorial. So, here it is asking about the response. So, observations are the response. So, we will select then going to term, it is also giving A B and AB ok, then in covariance, there is nothing in optional, there is a 95 percent confident interval and 2 sided in stepwise, it is ok, then graph will again 4 in 1 and also we will get the normal plot we do not want parrot of polar plot and ok.

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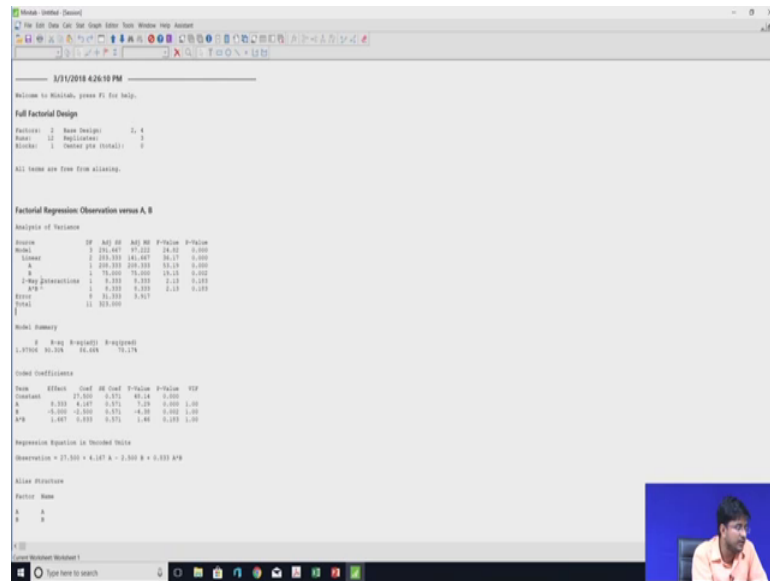
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We will also get all the result and model summary ANOVA table regression equation same manner according to your requirement, you can change and you can tick accordingly we will go to the ok.

So, will get the residual plot of the observation this is the normal probability plot and also with will get the ANOVA table.

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So, this is the ANOVA table. So, in ANOVA table it is also saying that for a what are the SS square value for B, what are the SS square value for AB; that is interaction, what is the SS square value and their degree of freedom value and also from there, we can calculate the MS square value and we can calculate also the F value and from F value we can give that whether A is affecting the mean rate or B is affecting which factors are mostly affecting the mean rate or not.

So, now, here we can see that there is one model the model is basically talking about all the things that there will be a there will be B there will be AB.

So, if we add the SS square value of A plus SS square value of B and plus SS square value of AB, then we will get this SS square value of model also there are there is one another one is linear. So, if we linear means only the factor A and B, we have to ignore the A B. So, if we add the SS square value of a and SS square value of B they will get the SS square value of linear. So, in the same manner we will get all the value and the degree of freedom.

So, now, we have we have also got the regression equation. So, in this way we can see that how MINITAB is very useful and very powerful software for analysing various problem of design and analysis ex experiment. So, in the next class, we will again analyse the fractional factorial design and also the response surface methodology in MINITAB that how to use MINITAB in that in that case so.

Thank you.