Design of Experiments - SigmaXL® Version 6.1

- DOE Overview
- Basic DOE Templates
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- Analyze Catapult DOE
- Predicted Response Calculator
- Response Surface Designs
- Contour & 3D Surface Plots

Design of Experiments

- Basic DOE Templates
  - Automatic update to Pareto of Coefficients
  - Easy to use, ideal for training
- Generate 2-Level Factorial and Plackett-Burman Screening Designs
- Main Effects & Interaction Plots
- Analyze 2-Level Factorial and Plackett-Burman Screening Designs

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Basic DOE Templates

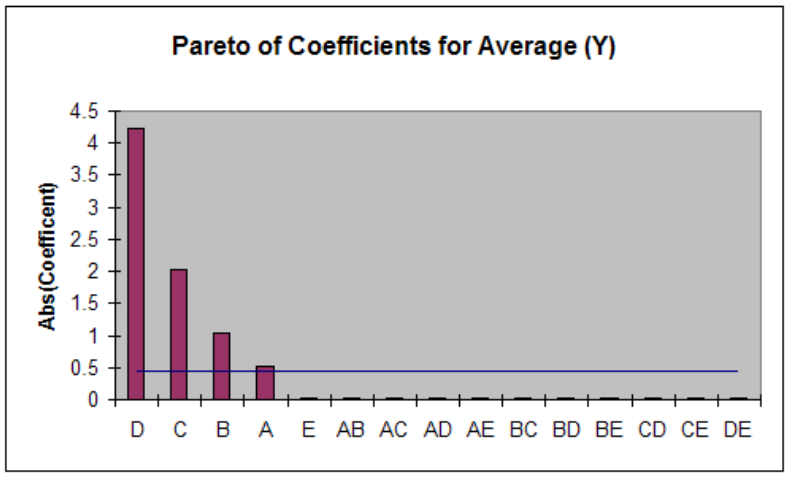
Five Factor, Two-Level, Half-Fraction Design of Experiments

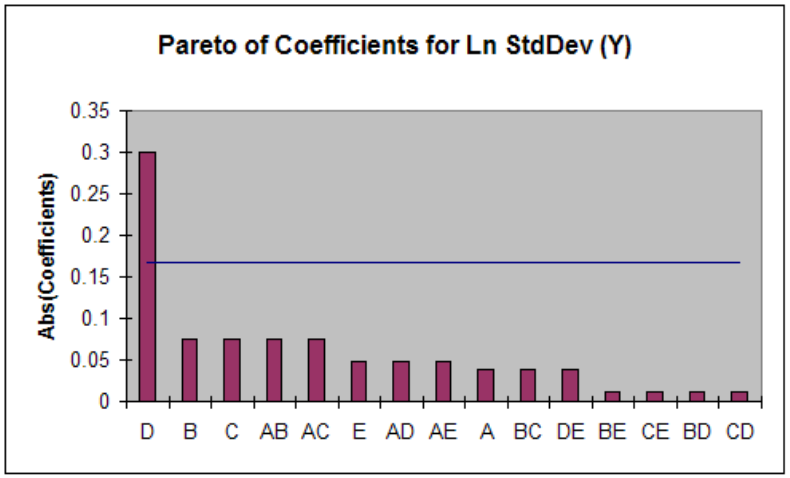
Title: Process Yield Improvement
Date: 21-May-04
Name of Experimenter: John Noguera
Response: Yield
Goal: Maximize

Factor	Factor Name	Low	High
A	Temperature	100	200
B	Power	50	100
C	Pressure	10	20
D	Speed	400	500
E	Catalyst	-1	1

Predicted Output for Y:

Factor Name	Enter Actual Factor Setting - uncoded	Factor setting coded	Y-hat:	S-hat:
Temper	150	0	9.25	1
Power	75	0		
Pressur	15	0		
Speed	450	0		
Catalys	1	1		





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Design of Experiments: Generate 2-Level Factorial and Plackett-Burman Screening Designs

- User-friendly dialog box
- 2 to 19 Factors
- 4,8,12,16,20 Runs
- Unique “view power analysis as you design”
- Randomization, Replication, Blocking and Center Points

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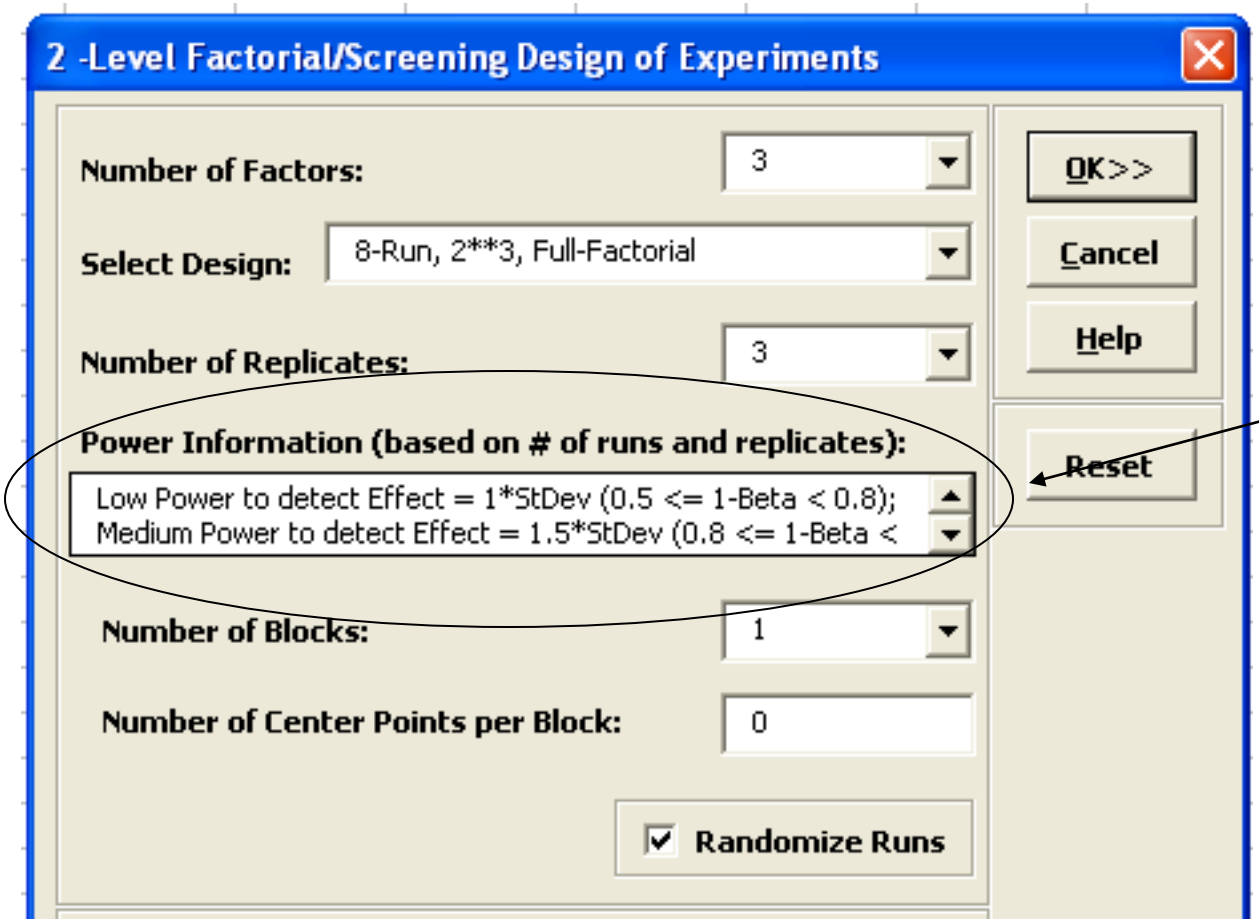
Design of Experiments: Generate 2-Level Factorial and Plackett-Burman Screening Designs



View Power Information as you design!

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Design of Experiments Example: 3-Factor, 2-Level Full-Factorial Catapult DOE

Objective: Hit a target at exactly 100 inches!

Design of Experiments Worksheet

Title: Catapult
Date: April 26 2006
Name of Experimenter: John Noguera
Notes:

Design Type: 3 Factor, 8-Run, 2**3, Full-Factorial
Number of Replicates: 3
Number of Blocks: 1
Number of Center Points per Block: 0
Number of Responses: 1

Run Order	Std. Order	Center Points	Blocks	A: Pull Back	B: Stop Pin	C: Pin Height	Distance
1	11	1	1	160	3	2	80
2	21	1	1	160	2	3	71
3	14	1	1	180	2	3	124
4	19	1	1	160	3	2	79
5	10	1	1	180	2	2	101
6	8	1	1	180	3	3	144
7	2	1	1	180	2	2	102
8	12	1	1	180	3	2	116

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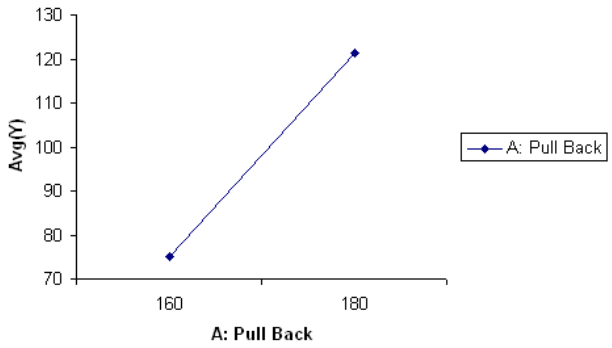
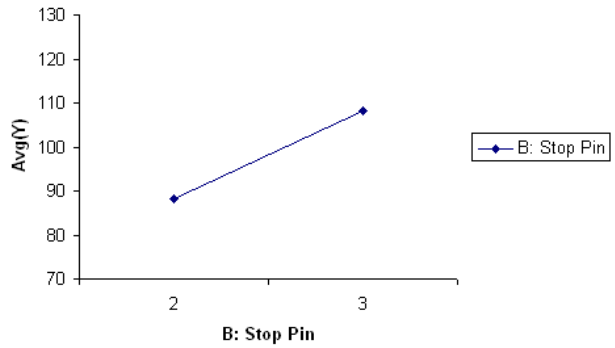
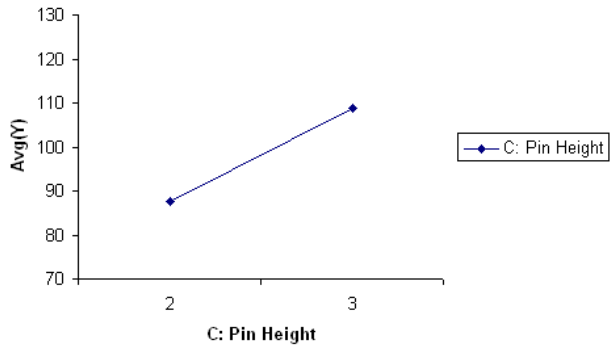
Design of Experiments: Main Effects and Interaction Plots

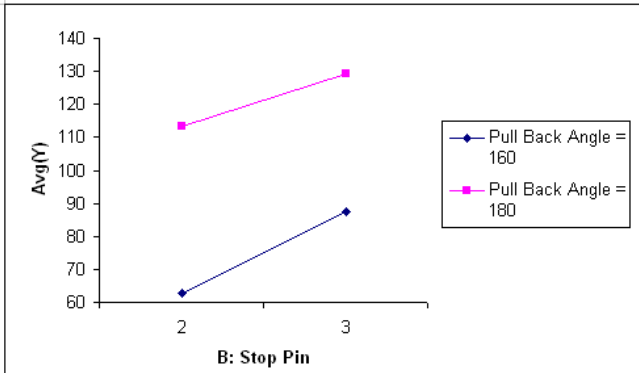
Main Effects Plots for Avg(Y)
Response: Distance

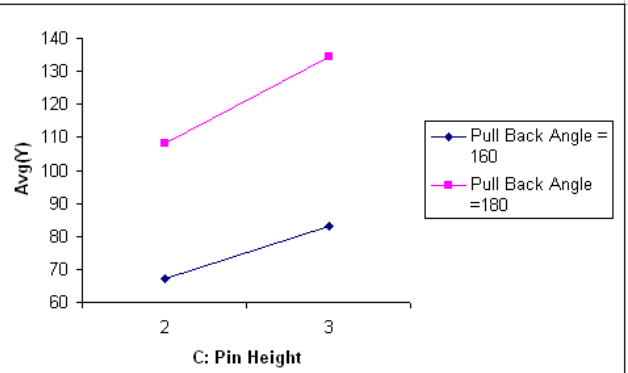






Interaction Plots for Avg(Y)
Response: Distance





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Design of Experiments: Analyze 2-Level Factorial and Plackett-Burman Screening Designs

- Used in conjunction with Recall Last Dialog, it is very easy to iteratively remove terms from the model
- Interactive Predicted Response Calculator with 95% Confidence Interval and 95% Prediction Interval.
- ANOVA report for Blocks, Pure Error, Lack-of-fit and Curvature
- Collinearity Variance Inflation Factor (VIF) and Tolerance report

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Design of Experiments: Analyze 2-Level Factorial and Plackett-Burman Screening Designs

- Residual plots: histogram, normal probability plot, residuals vs. time, residuals vs. predicted and residuals vs. X factors
- Residual types include Regular, Standardized, Studentized (Deleted t) and Cook's Distance (Influence), Leverage and DFITS
- Highlight of significant outliers in residuals
- Durbin-Watson Test for Autocorrelation in Residuals with p-value

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Design of Experiments Example: Analyze Catapult DOE

DOE Multiple Regression Model: Distance = (98.20833333) + (23.125) * A: Pull Back + (10.125) * B: Stop Pin + (10.54166667) * C: Pin Height + (-2.125) * AB + (2.458333333) * AC + (0.625) * BC + (0.708333333) * ABC

Model Summary:

R-Square	99.95%
R-Square Adjusted	99.93%
S (Root Mean Square Error)	0.763763

Parameter Estimates:

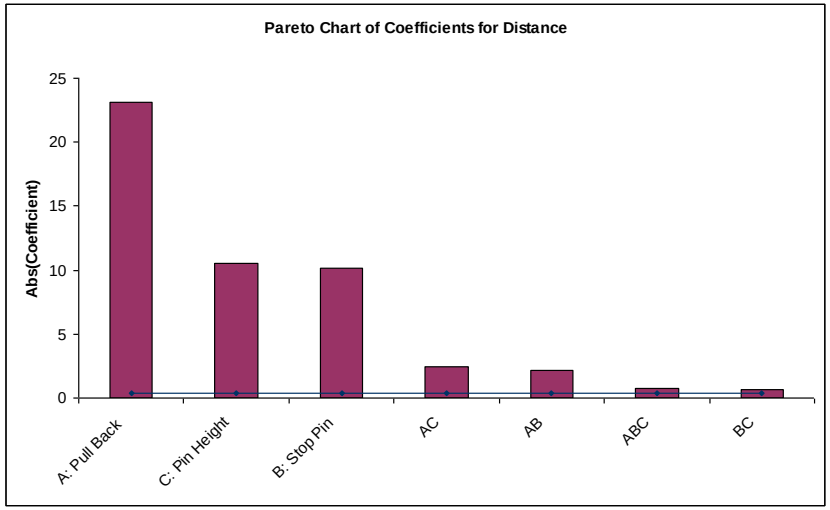
Term	Coefficient	SE Coefficient	T	P	VIF	Tolerance
Constant	98.20833333	0.155902391	629.93	0.0000		
A: Pull Back	23.125	0.155902391	148.33	0.0000	1	1
B: Stop Pin	10.125	0.155902391	64.944	0.0000	1	1
C: Pin Height	10.54166667	0.155902391	67.617	0.0000	1	1
AB	-2.125	0.155902391	-13.630	0.0000	1	1
AC	2.458333333	0.155902391	15.768	0.0000	1	1
BC	0.625	0.155902391	4.0089	0.0010	1	1
ABC	0.708333333	0.155902391	4.5434	0.0003	1	1

Analysis of Variance for Model:

Source	DF	SS	MS	F	P
Model	7	18237	2605.2	4466.1	0.0000
Error	16	9.3333	0.583333		
Pure Error	16	9.3333	0.583333		
Total (Model + Error)	23	18246	793.30		

Durbin-Watson Test for Autocorrelation in Residuals:

DW Statistic	2.0595
P-Value Positive Autocorrelation	0.5572
P-Value Negative Autocorrelation	0.4357



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Design of Experiments: Predicted Response Calculator

Predicted Response Calculator:

Predictors	Enter Actual Settings:	Coded Settings	Predicted Response	Lower 95% CI	Upper 95% CI	Lower 95% PI	Upper 95% PI
A:	179.3	0.93	100.0216667	99.119	100.924	98.168	101.875
B:	2	-1					
C:	2	-1					

95% Confidence Interval and Prediction Interval

Excel's Solver is used with the Predicted Response Calculator to determine optimal X factor settings to hit a target distance of 100 inches.

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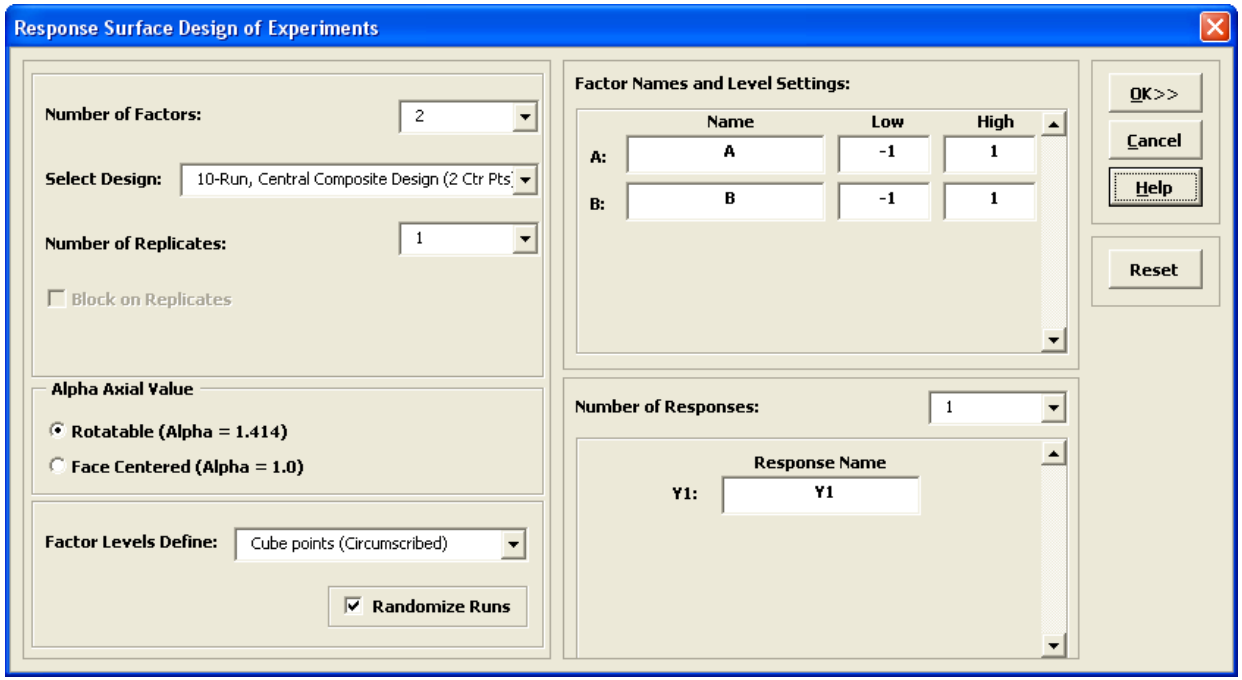
Design of Experiments: Response Surface Designs

- 2 to 5 Factors
- Central Composite and Box-Behnken Designs
- Easy to use design selection sorted by number of runs:



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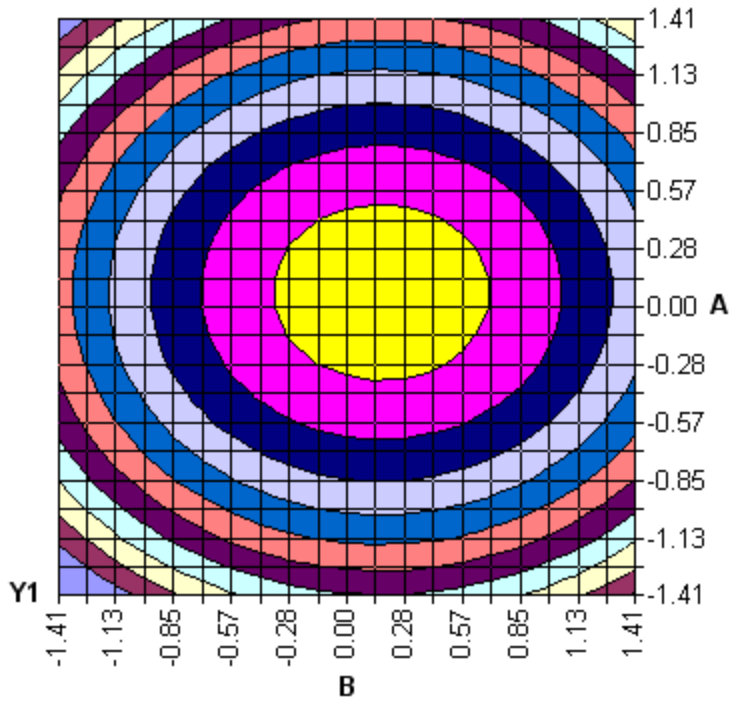
Design of Experiments: Contour & 3D Surface Plots

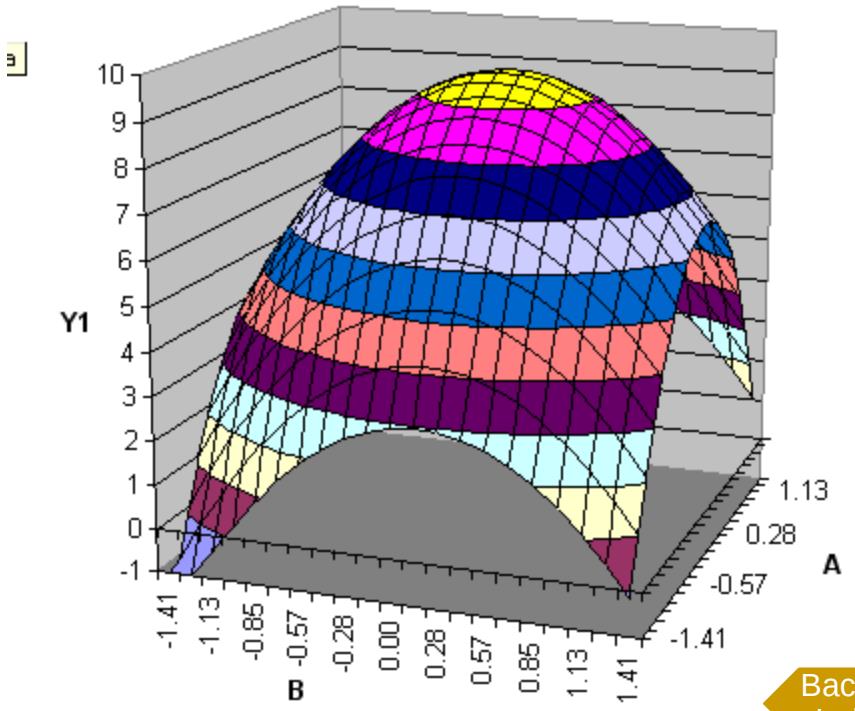
RSM Multiple Regression Model:

$$Y1 = (9.5) + (0.43) * A: A + (0.68) * B: B + (0) * AB + (-3) * AA + (-2) * BB$$

RSM Contour Plot



RSM 3D Surface Plot



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