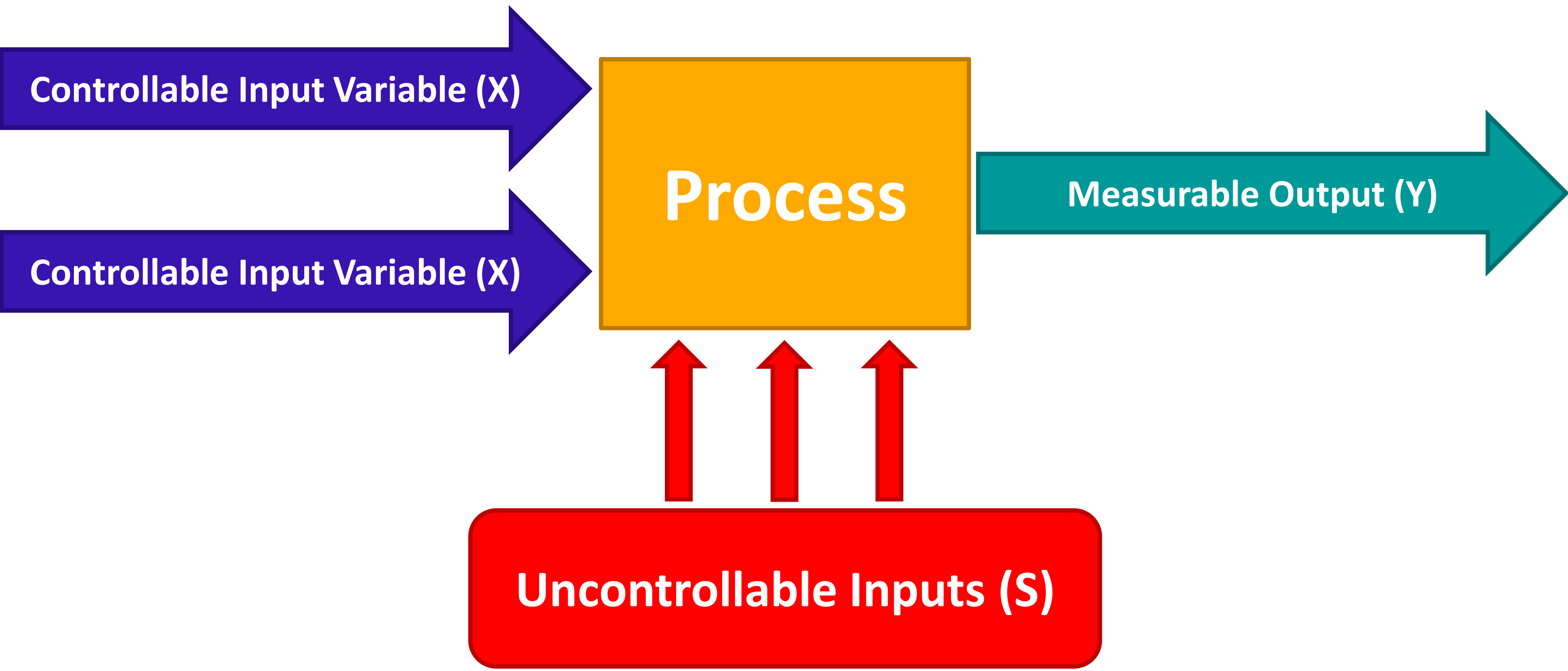
Design of Experiments (DOE) Example

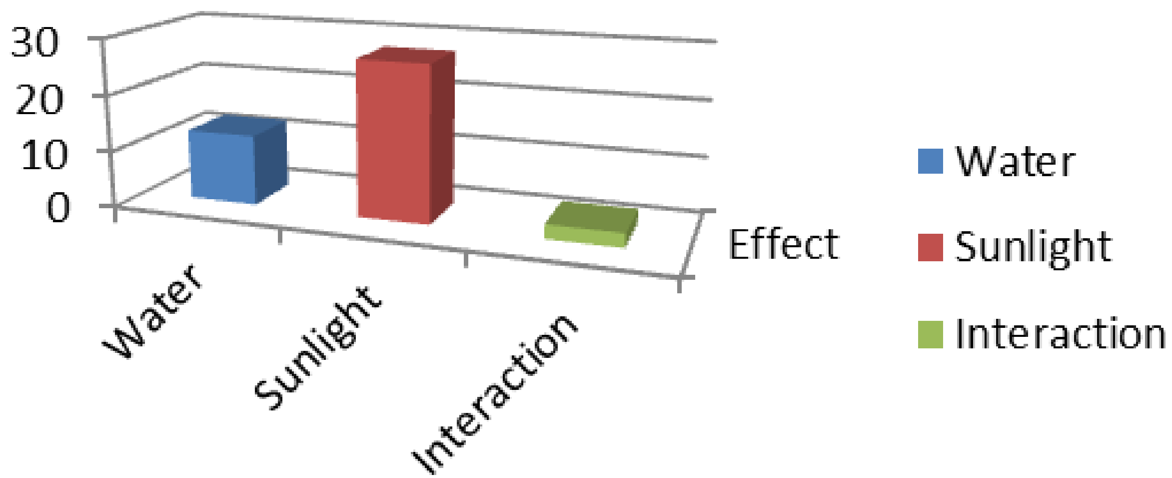


Design of Experiments (DOE) Example

StdOrder	RunOrder	CenterPt	Blocks	A	B	Growth
2	1	1	1	1.5	1	30
3	2	1	1	0.5	3	45
4	3	1	1	1.5	3	60
1	4	1	1	0.5	1	20

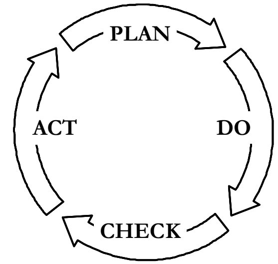
Term Constant		Effect
A	Water	12.5
B	Sunlight	27.5
A*B	Interaction	2.5

Effect on Plant Growth



Design of Experiments (DOE) Reference Card

TYPE	TEST STATISTIC	DF	APPLICATION
Z	$Z = \dfrac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}}$	N.A.	Single sample mean. Standard deviation of population is known
t Test	$t = \dfrac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$	n - 1	Single sample mean. Standard deviation of population unknown
2 MEAN EQUAL VARIANCE t TEST	$t = \dfrac{\bar{X}_1 - \bar{X}_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$	$n_1 + n_2 - 2$	2 sample means. σ_1 and σ_2 are unknown, but considered equal
2 MEAN UNEQUAL VARIANCE t TEST	$t = \dfrac{X_1 - X_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$	$\dfrac{1}{\dfrac{\left(\dfrac{\frac{S_1^2}{n_1}}{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}\right)^2}{n_1 - 1} + \dfrac{\left(\dfrac{\frac{S_2^2}{n_2}}{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}\right)^2}{n_2 - 1}}$	2 sample means. σ_1 and σ_2 are unknown, but considered unequal
PAIRED t TEST	$t = \dfrac{\frac{\bar{d}}{S_d}}{\sqrt{n}}$	n -1	2 sample means. Data is taken in pairs. A different d is calculated for each pair
X^2 σ KNOWN	$X^2 = \dfrac{(n-1)S^2}{\sigma^2}$	n -1	Tests sample variance against known variance.
X^2 σ UNKNOWN	$X^2 = \sum \dfrac{(O-E)^2}{E}$	(r-1)(c-1)	Compares variances between samples when σ^2 is unknown. Used for attribute data.
F	$F = \dfrac{(S_1)^2}{(S_2)^2}$	$n_1 - 1$ $n_2 - 1$	Tests if two sample variances are equal.



10 Steps to Experimental

1. Objective
2. Team
3. Characteristic
4. Capability (GR&R)
5. Factors
6. Levels
7. Exp. Plan
8. Run Experiment
9. Analyse
10. Action

X = the sample mean
μ = population mean
σ= population standard deviation
n = number of test samples
S = sample standard deviation
DF = Degrees of Freedom
S_p = pooled standard deviation

$$\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$$

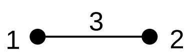
Note: Tables are required to determine the significance of the test statistic. Tables can be obtained from many different statistical reference texts

Design of Experiments (DOE) Reference Card

Orthogonal Arrays

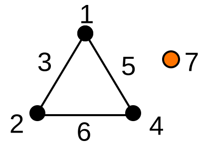
L_4 (2^3)

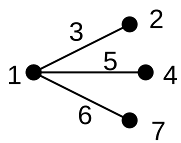
Condition	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1



L_8 (2^7)

Condition	1	2	3	4	5	6	7
1	1	1	1	1	1	1	1
2	1	1	1	2	2	2	2
3	1	2	2	1	1	2	2
4	1	2	2	2	2	1	1
5	2	1	2	1	2	1	2
6	2	1	2	2	1	2	1
7	2	2	1	1	2	2	1
8	2	2	1	2	1	1	2





L9 (3^4)

Condition	1	2	3	4
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

ANOVA Table

Factors	Degrees of Freedom f	Sum of Squares S	Mean Sqrs. V	F Ratio F	Percent Contrib. ρ
A					
B					
C					
D					
Error					
Total					

Degrees of Freedom

f = number of levels – 1

(mean) $f_m = 1$ (always)

(Total) f_T = (# of conditions X #of reps) – 1

(Error) $F_e = f_T - f_A - f_B - \ldots\ldots$

Sum of Squares

$S =$ (each observation – $X)^2$

(mean) $S_m = S/f$

(Total) $S_T = \sum$ (each observation – $X)^2$

(Error) $S_e = S_T - S_m$

Mean Square

$V = S / f$

(Total) $V_T = S_T / f_T$

(mean) $V_m = S_m / f_m$

(Error) $V_e = (S_T - S_m) / f_e$

F Ratio

$F_A = V_A / V_e$

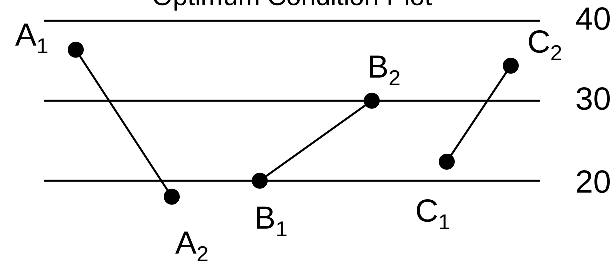
Percent Contribution

$\rho = (S / S_T) \times 100$

	Factors			
Condition	A	B	C	
1	1	1	1	35
2	1	2	2	30
3	2	1	2	25
4	2	2	1	10

	Factors		
Level	A	B	C
1	37.5	30	22.5
2	17.5	20	27.5

Optimum Condition Plot



Optimum Condition (Bigger the Better) is A_1, B_2, C_2

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