#	1-Tailed Hyp	2-Tailed Hyp	Assumptions	Formulas	Decision	CI (2-Sided)
1	**1 Sample Z-Test** $Ho:\mu=5$ $Ha:\mu>5$	$Ho:\mu=3$ $Ha:\mu\neq 3$	-Random Sample -Data is Normally Distributed (CLT)	$Z_{stat}=\frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$	Reject Ho if $\lvert Z_{stat}\rvert > \lvert Z_{crit}\rvert$* or $p<\alpha$	$\bar{x} \pm Z_{\alpha/2}\,\sigma/\sqrt{n}$
2	**1 Sample T-Test** $Ho:\mu=6$ $Ha:\mu>6$	$Ho:\mu=8$ $Ha:\mu\neq 8$	-Random Sample -Data is Normally Distributed (CLT)	$T_{stat}=\frac{\bar{x}-\mu}{s/\sqrt{n}}$ $df = n-1$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$* or $p<\alpha$	$\bar{x} \pm T_{\alpha/2}\, s/\sqrt{n}$
3	**Paired T-Test** $Ho:\mu_d=0$ $Ha:\mu_d<0$	$Ho:\mu_d=0$ $Ha:\mu_d\neq 0$	-Dependent Samples -Sample of Diff is Normally Distributed	$T_{stat}=\frac{\bar{d}-\mu_d}{s_d/\sqrt{n}}$ $df = n-1$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$* or $p<\alpha$	$\bar{d} \pm T_{\alpha/2}\, s_d/\sqrt{n}$
4	**2 Sample T-Test** $Ho:\mu_1-\mu_2=0$ $Ha:\mu_1-\mu_2<0$	$Ho:\mu_1-\mu_2=0$ $Ha:\mu_1-\mu_2\neq 0$	-Independent Samples -Each Sample is Normally Distributed -Population Variances are Equal	$T_{stat}=\frac{(\bar{x}_1-\bar{x}_2)-(\mu_1-\mu_2)}{s_p\sqrt{(1/n_1+1/n_2)}}$ $s_p=\sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}}$ $df = n_1+n_2-2$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$* or $p<\alpha$	$(\bar{x}_1-\bar{x}_2) \pm T_{\alpha/2}{}^* s_p\sqrt{(1/n_1+1/n_2)}$
5	**2 Sample T-Test** $Ho:\mu_1-\mu_2=0$ $Ha:\mu_1-\mu_2<0$	$Ho:\mu_1-\mu_2=0$ $Ha:\mu_1-\mu_2\neq 0$	-Independent Samples -Each Sample is Normally Distributed -Population Variances are NOT Equal	$T_{stat}=\frac{(\bar{x}_1-\bar{x}_2)-(\mu_1-\mu_2)}{\sqrt{(s_1^2/n_1+s_2^2/n_2)}}$ $df=\frac{(s_1^2/n_1+s_2^2/n_2)^2}{\left(\frac{(s_1^2/n_1)^2}{n_1-1}+\frac{(s_2^2/n_2)^2}{n_2-1}\right)}$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$* or $p<\alpha$	$(\bar{x}_1-\bar{x}_2) \pm T_{\alpha/2}{}^* \sqrt{(s_1^2/n_1+s_2^2/n_2)}$
7	**Wilcoxin** $Ho:M_d=0$ $Ha:M_d<0$	$Ho:M_d=0$ $Ha:M_d\neq 0$	-Dependent Samples -Sample of Diff is NOT Normally Distributed	p-value = from Minitab output	Reject Ho if $p<\alpha$	Minitab
8	**Mann-Whitney** $Ho:M_1-M_2=0$ $Ha:M_1-M_2<0$	$Ho:M_1-M_2=0$ $Ha:M_1-M_2\neq 0$	-Independent Samples -One or both of the samples is NOT normally distributed	p-value = from Minitab output	Reject Ho if $p<\alpha$	Minitab
9	**1 Proportion** $Ho:p=0.3$ $Ha:p<0.3$	$Ho:p=0.4$ $Ha:p\neq 0.4$	$-np \geq 10$ $-nq \geq 10$	$Z_{stat}=\frac{\hat{p}-p}{\sqrt{(pq/n)}}$ $\hat{p}=x/n \quad \hat{q}=1-\hat{p}$	Reject Ho if $\lvert Z_{stat}\rvert > \lvert Z_{crit}\rvert$* or $p<\alpha$	$\hat{p} \pm Z_{\alpha/2}\sqrt{(\hat{p}\hat{q}/n)}$
10	**2 Proportions** $Ho:p_1-p_2=0.0$ $Ha:p_1-p_2<0.0$ (Independent Pooled)	$Ho:p_1-p_2=0.0$ $Ha:p_1-p_2\neq 0.0$	$-n_1\hat{p}_1 \geq 10$ $-n_1\hat{q}_1 \geq 10$ $-n_2\hat{p}_2 \geq 10$ $-n_2\hat{q}_2 \geq 10$	$Z_{stat}=\frac{(\hat{p}_1-\hat{p}_2)-(p_1-p_2)}{\sqrt{\bar{p}(1-\bar{p})(1/n_1+1/n_2)}}$ $\bar{p}=(n_1\hat{p}_1+n_2\hat{p}_2)/(n_1+n_2)$ $\hat{p}_1=x_1/n_1 \quad \hat{p}_2=x_2/n_2$	Reject Ho if $\lvert Z_{stat}\rvert > \lvert Z_{crit}\rvert$* or $p<\alpha$	$(\hat{p}_1-\hat{p}_2) \pm Z_{\alpha/2}{}^* \sqrt{(\hat{p}_1\hat{q}_1/n_1+\hat{p}_2\hat{q}_2/n_2)}$
11	**2 Proportions** $Ho:p_1-p_2=0.1$ $Ha:p_1-p_2<0.1$ (Independent)	$Ho:p_1-p_2=0.1$ $Ha:p_1-p_2\neq 0.1$	$-n_1\hat{p}_1 \geq 10$ $-n_1\hat{q}_1 \geq 10$ $-n_2\hat{p}_2 \geq 10$ $-n_2\hat{q}_2 \geq 10$	$Z_{stat}=\frac{(\hat{p}_1-\hat{p}_2)-(p_1-p_2)}{\sqrt{(\hat{p}_1\hat{q}_1/n_1+\hat{p}_2\hat{q}_2/n_2)}}$ $\hat{p}_1=x_1/n_1 \quad \hat{p}_2=x_2/n_2$	Reject Ho if $\lvert Z_{stat}\rvert > \lvert Z_{crit}\rvert$* or $p<\alpha$	$(\hat{p}_1-\hat{p}_2) \pm Z_{\alpha/2}{}^* \sqrt{(\hat{p}_1\hat{q}_1/n_1+\hat{p}_2\hat{q}_2/n_2)}$
12	**2 Proportions** $Ho:p_1-p_2=0.0$ $Ha:p_1-p_2<0.0$ (Dependent, $\hat{p}_1$ and $\hat{p}_2$ from same sample)	$Ho:p_1-p_2=0.0$ $Ha:p_1-p_2\neq 0.0$	$-n\hat{p}_1 \geq 10$ $-n\hat{q}_1 \geq 10$ $-n\hat{p}_2 \geq 10$ $-n\hat{q}_2 \geq 10$	$Z_{stat}=\frac{(\hat{p}_1-\hat{p}_2)-(p_1-p_2)}{\sqrt{(\hat{p}_1\hat{q}_1/n+\hat{p}_2\hat{q}_2/n+2\hat{p}_1\hat{p}_2/n)}}$ $\hat{p}_1=x_1/n \quad \hat{p}_2=x_2/n$	Reject Ho if $\lvert Z_{stat}\rvert > \lvert Z_{crit}\rvert$* or $p<\alpha$	$(\hat{p}_1-\hat{p}_2) \pm Z_{\alpha/2}{}^* \sqrt{(\hat{p}_1\hat{q}_1/n+\hat{p}_2\hat{q}_2/n+2\hat{p}_1\hat{p}_2/n)}$

CI (1-Sided)
- All CI formulas will be the same as the sided formulas EXCEPT you will use 1 tailed T_α and Z_α
- If the Ha has a ">" sign, only do "-" calc. Format ->(# calculated , infinity)
- If the Ha has a "<" sign, only do "+" calc Format ->(-infinity, # calculated)

Variables

- E=margin of error
- μ = pop. mean
- $\bar{x}$ = sample mean
- σ = pop. SD
- s = sample SD
- σ^2 = pop. variance
- s^2 = sample variance
- μ_d = pop. mean of differences
- $\bar{d}$ = sample mean of differences
- s_d = sample SD of differences
- s_p = pooled SD
- n = sample size
- M_d = pop. median of differences
- M= pop. median
- p = pop. proportion
- $\hat{p}$ = sample proportion
- $\bar{p}$ = pooled proportion

Testing Steps

1) Write Hypothesis
2) Calculate STAT Value
3) Calculate CRIT Value
4) Make Decision
5) Concluding Sentence

*If 1 tailed and you have a "<" sign in Ha, reject Ho if $Z_{stat} < Z_{crit}$ or $T_{stat}<T_{crit}$. If 1 tailed and you have a ">" sign in Ha, reject Ho if $Z_{stat} > Z_{crit}$ or $T_{stat}>T_{crit}$

12 **1-WAY ANOVA**

$Ho:\mu_1=\mu_2=\mu_3=\ldots\mu_n$

Ha:not all means equal

Assumptions
- Samples Normal
- Equal Variances
- Observations Ind

***Review 1 WAY ANOVA table in the book for detailed calculations.

$F_{stat}=MS_{fac}/MS_{err}$

Reject Ho if $\lvert F_{stat}\rvert > \lvert F_{crit}\rvert$ or $p<\alpha$.

Both F_{stat} and p come from minitab.

$df_f=k-1$ $df_e=N-k$ $df_t=N-1$

13 **2-WAY ANOVA**

Assumptions
- See 1-Way ANOVA

**Review 2 WAY ANOVA table in the book for detailed calculations.

3 Possible Tests

Test #1-Interaction	Test #2-Factor A Means	Test #3-Factor B Means
Ho: Factors A and B do not Interact Ha:Factors A and B Interact	$Ho:\mu_{1a}=\mu_{2a}=\ldots\mu_{na}$ Ha:not all means equal	$Ho:\mu_{1b}=\mu_{2b}=\ldots\mu_{nb}$ Ha:not all means equal
$F_{stat}=MS_{Int}/MS_{err}$	$F_{stat}=MS_{facA}/MS_{err}$	$F_{stat}=MS_{facB}/MS_{err}$

Main Effect

For all 3 tests Reject Ho if $\lvert F_{stat}\rvert > \lvert F_{crit}\rvert$ or $p<\alpha$. There will be 3 F-values and/or p-values in minitab.

$df_{f1}=r-1$ $df_{f2}=c-1$ $df_{int}=(r-1)*(c-1)$ $df_{err}=r*c*(n-1)$ $df_{tot}=N-1$

19 **ANOVA-BLOCKED**

Assumptions
- See 1-Way ANOVA

**Review BLOCKED ANOVA table in the book for detailed calculations.

2 Possible Tests

Test #1-Was Blocking Needed?	Test #2-Factor Means	
$Ho:\mu_{bl1}=\mu_{bl2}=\ldots\mu_{bln}$ Ha:not all block means equal	$Ho:\mu_{a1}=\mu_{a2}=\ldots\mu_{an}$ Ha:not all factor means equal	***If in test #1 we DO NOT reject Ho we must run a 1-WAY ANOVA to complete test #2, otherwise, you can proceed with test #2 using the output.
$F_{stat}=MS_{block}/MS_{err}$	$F_{stat}=MS_{facA}/MS_{err}$	

For both tests Reject Ho if $\lvert F_{stat}\rvert > \lvert F_{crit}\rvert$ or $p<\alpha$. There will be 2 F-values and/or p-values in minitab.

Run a 1-way ANOVA

$df_{block}=b-1$ $df_{fac}=c-1$ $df_{err}=(b-1)*(c-1)$ $df_{tot}=N-1$

- **Bonferroni** used to identify where the actual differences between means are.

critical difference = $t_{\alpha/2J}$ * s_b*SQRT($1/n_1$ + $1/n_2$) s_b=SQRT(MSE) J=[(rc)*(rc-1)]/2

Interval = actual difference +/- $t_{\alpha/2J}$ * s_b*SQRT($1/n_1$ + $1/n_2$) J=number of comparisons

- if the interval contains "0", there is no difference between the means being compared
- Used for 1-WAY ANOVA and 2-WAY ANOVA, do not use for BLOCKED ANOVA

- **Correlation**

- Measure the relationship between 2 variables
- Always between 1 and -1
- The closer to 1 or -1 the stronger the relationship

$Ho:\rho=0$ $Ha:\rho\neq 0$ $Ho:\rho=0$ $Ha:\rho>0$

$T_{stat}=\frac{r}{\sqrt{\frac{1-r^2}{n-1}}}$ df = n-2

- "r" is calculated by minitab
- Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$ or $p<\alpha$

Variance Inflation Factor (VIF)

Multicollinearity is a problem caused by highly correlated independent variables. It is a problem if VIF>10. VIF = $1/(1-R^2)$

between 5 & 10 -> small problem

14 **Simple Regression**

Assumptions
- Error Terms Norm Dist.
- Constant Variance
- Error Terms Ind.
- Linear Model

2 PossibleTests

Test #1-Significance of Model	Test #2-Significance of Variable in Model
$Ho:B_1=0$ $Ha:B_1\neq 0$	$Ho:B_n=0$ $Ha:B_n\neq 0$ $T_{stat}=\frac{b_n-B_n}{s_{bn}}$ df = n-2
$F_{stat}=MS_{reg}/MS_{err}$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$ or $p<\alpha$
Reject Ho if $\lvert F_{stat}\rvert > \lvert F_{crit}\rvert$ or $p<\alpha$.	All numbers come from minitab.

-Regression Equation Given in Output as $\hat{y}=c+B_1x_1$

-Residual= actual value - value predicted by model by subbing "x" into equation

15 **Multiple Regression**

Assumptions
- Error Terms Norm Dist.
- Constant Variance
- Error Terms Ind.
- Linear Model

2 PosTypes of Tests

Test #1-Significance of Model	Test #2-Significance of Variable in Model
B= coefficient $Ho:B_1=B_2=B_3\ldots=B_n=0$ Ha:Atleast one $B_n\neq 0$ ↳2-tail	b_0 = sample coefficient $Ho:B_n=0$ $Ha:B_n\neq 0$ ↳2-tail $T_{stat}=\frac{b_n-B_n}{s_{bn}}$ (→0) df=n-k-1
$F_{stat}=MS_{reg}/MS_{err}$	Reject Ho if $\lvert T_{stat}\rvert > \lvert T_{crit}\rvert$ or $p<\alpha$
Reject Ho if $\lvert F_{stat}\rvert > \lvert F_{crit}\rvert$ or $p<\alpha$.	-All numbers come from minitab. -This test can be repeated for each independent variable.

$R^2 = 1-(SS_{err}/SS_{tot})$ $R^2_{adj}= 1-(MS_{err}/MS_{tot}) = MS_{reg}/MS_{tot}$

CI = fit +/- $T_{\alpha/2}$ *SE_{fit} PI = fit +/- $T_{\alpha/2}$ *SQRT(SE_{fit}^2 + SE_{model}^2)

-Regression Equation Given in Output as $\hat{y}=c+B_1x_1+B_2x_2+\ldots+B_nx_n$

-Residual= actual value - value predicted by model by subbing independent variables into the regression equation.

-The best model will be the one with the highest R^2, the lowest S and the lowest number of ind. variables.

$df_{reg}=k$ $df_{err}=n-k-1$ $df_{tot}=n-1$

$S=\sqrt{MSE}$

1-tail=(< or >) 2-tail=(≠)