TOPIC: ONE-WAY ANOVA

Introduction to One-Way Analysis of Variance

◆ Recall: To compare 2 means, we used a t-test. For 3+ means, use **ANOVA**.

  ▶ **Variance *Between:*** How _____ groups are from each other.

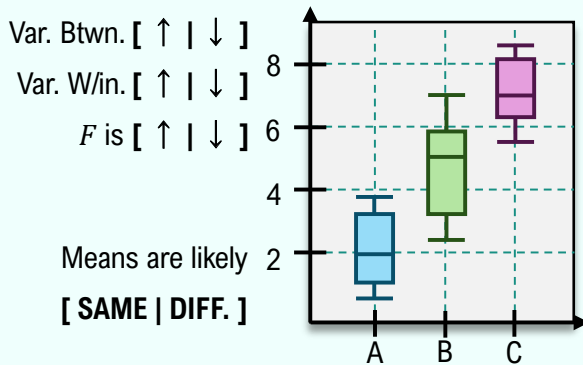 ▶ **Variance *Within:*** How _____ each individual group is.

New

$$F = \frac{variance \quad\quad groups}{variance \quad\quad groups}$$
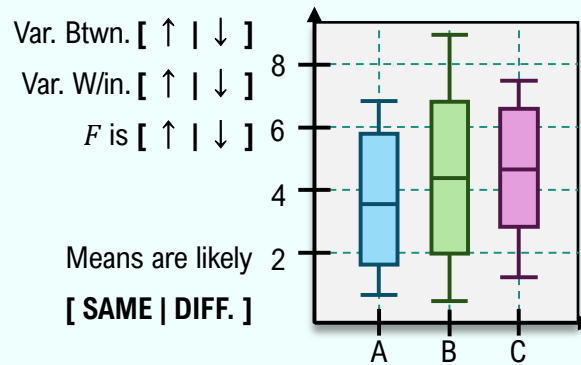

EXAMPLE

The boxplots below show the distribution of data in three groups. Determine which dataset will have the higher F-Statistic. For each graph, is it likely that the 3 means are the same?

(**A**)

Var. Btwn. **[↑ | ↓]**

Var. W/in. **[↑ | ↓]**

F is **[↑ | ↓]**

Means are likely

[SAME | DIFF.]

A   B   C

(**B**)

Var. Btwn. **[↑ | ↓]**

Var. W/in. **[↑ | ↓]**

F is **[↑ | ↓]**

Means are likely

[SAME | DIFF.]

A   B   C

A company wants to determine whether the average monthly sales differ among three different regions: North, South, and West. The company collects monthly sales data (in thousands of dollars) from four randomly selected stores in each region over the same month. Calculate the F-Statistic given the Mean Square due to Treatments: $\text{MST} = 226.6$ (variance *between* groups) and the Mean Square due to Error: $\text{MSE} = 7.944$ (variance *within* groups).

Recall

$$F = \frac{variance\ between\ groups}{variance\ within\ groups}$$

Four different high schools in local towns took random samples of 100 students in three grades, 10th-12th and collected data on the weekly time spent studying to see if students in each of these grades study on average for the same amount of time per week. The four schools ran ANOVA tests on their samples, and the F-Statistics were 2.35, 2.57, 2.81 and 3.93. Which F-Statistic is most likely to indicate the average study times across grades are not all the same?

TOPIC: ONE-WAY ANOVA

One-way ANOVA Test

◆ Recall: **ANOVA** compares 3+ means by analyzing variance between & within groups (aka samples, treatments, levels).

EXAMPLE

The graph below shows weekly study times (in hours) from a random, independent sample of $N = 100$ 10th-12th graders. Test the claim that students across these grades study on average for the same amount of time, using $\alpha = 0.05$, $F = 2.14$. Assume the population distributions are normal with approximately the same variances.

New

Analysis Of Variance

1)

H_0: All means are the same; $\mu_1 = \mu_2 = \cdots = \mu_k$
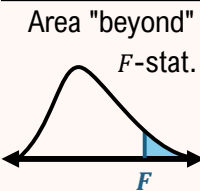
H_a: At least ____ mean is _____ from the others.

2)

Recall

$$F = \frac{variance\ between\ groups}{variance\ within\ groups}$$

F-stat = _____

3)

Area "beyond" F-stat.

$df_{num} = k - 1$
$df_{denom} = N - k$
(k = # of groups)
(N = # of total obs.)

$df_{num} =$ _____
$df_{denom} =$ _____
P-value = _____

F

4)

Because P-value **[< | >]** α, we **[REJECT | FAIL TO REJECT]** H_0. There is **[ENOUGH | NOT ENOUGH]** evidence to suggest that at least one mean is significantly different.
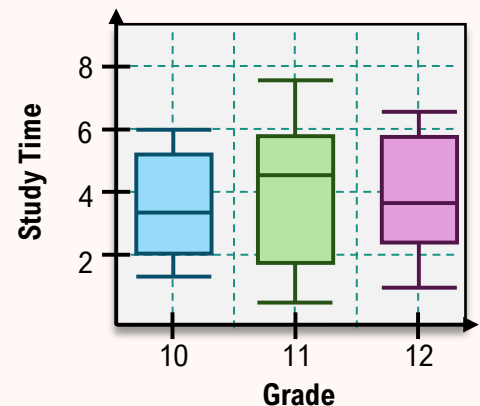
Criteria

Random samples?	☐	Groups Have Approx. Norm. Dist.?	☐
Independent Samples?	☐	Groups Have Approx. Same Variance?	☐

Study Time vs Grade box plot (Study Time axis: 2, 4, 6, 8; Grade axis: 10, 11, 12)

TOPIC: ONE-WAY ANOVA

A school administrator wants to examine whether students' academic performance differs based on the type of instructional method used in their classes. A random sample of 18 students is selected and divided evenly among the three teaching methods. After a semester, all students take the same standardized final exam.

Method	Test Scores					
Traditional	78	85	82	76	80	79
Flipped	88	90	92	87	85	89
Online	75	70	68	72	74	73

(A) State the null and alternative hypotheses for a one-way ANOVA test.

(B) An ANOVA test is performed and results in a P-value of $1.403 \cdot 10^{-7}$.
     Interpret these results.

TOPIC: ONE-WAY ANOVA

A marketing manager wants to evaluate whether three different advertising platforms–TV, social media, and print media–lead to different average sales performance across regional stores. She runs a 4-week advertising campaign, assigning one platform to a group of 5 stores each (15 stores total). After the campaign, she collects the average weekly sales (in $1,000s) for each store during the campaign period. She wants to determine whether there is a statistically significant difference in mean sales among the three advertising platforms.

Platform	Weekly Sales				
TV	23	25	24	22	23
Social Media	28	27	29	30	26
Print Media	22	21	23	24	22

(A) State the null and alternative hypotheses for a one-way ANOVA test.

(B) In an ANOVA test, a P-value of 0.03 is obtained. What can be concluded about mean weekly sales for different advertising platforms?

TOPIC: ONE-WAY ANOVA

Performing One-Way ANOVA Using a TI-84

◆ The calculations for ANOVA are very complicated, so use technology to perform ANOVA tests.

EXAMPLE

The table shows the weekly study times (in hours) from an independent, random sample of 10th-12th graders. Test the claim that students across these grades study on average for the same amount of time, using $\alpha = 0.05$.

Grade	Weekly Study Times (hrs)									
10	3	4	4	2	1	0	3	6	5	2
11	4	5	6	3	7	8	2	3	1	4
12	7	5	8	3	6	7	8	5	9	2

Random Samples?　□　　Groups Have Approx. Norm. Dist.?　□

Independent Samples?　□　　Groups Have Approx. Same Variance?　□

H_0:

H_a:

$F =$ _____

P-value = _____

Because P-value [< | >] α, we [REJECT | FAIL TO REJECT] H_0.

There is [ENOUGH | NOT ENOUGH] evidence to suggest that at least one grade has a significantly different mean study time.

HOW TO: Perform ANOVA on TI-84

1) STAT, 1:Edit…

　Enter data in L₁, L₂, L₃, …

2) STAT > TESTS

　H:ANOVA(

3) Enter lists, separated by commas

　ANOVA(L₁, L₂, L₃, …)

TOPIC: ONE-WAY ANOVA

A regional sales director wants to determine whether different customer service training programs lead to different levels of employee performance across three branches. Each branch uses one of the following training programs: Program A, Program B, or Program C. After one month, the director measures the performance score (out of 100) for 5 randomly selected employees from each branch. Using $\alpha = 0.05$, perform a one-way ANOVA to determine whether there is a statistically significant difference in mean performance among the three training programs.

Program	Performance Scores				
A	23	25	24	22	23
B	28	27	29	30	26
C	22	21	23	24	22

HOW TO: Perform ANOVA on TI-84

1) STAT, 1:Edit…

   Enter data in L₁, L₂, & L₃

2) STAT, > TESTS

   H:ANOVA(

3) Enter lists, separated by commas

   ANOVA(L₁, L₂, L₃)

EXAMPLE

A nutritionist wants to compare the effectiveness of three different diet plans (Diet A, Diet B, and Diet C) in terms of weight loss over a 6-week period. She randomly assigns 15 participants to one of the three diet groups, with 5 participants per group. After 6 weeks, the amount of weight (in pounds) lost by each participant is recorded. Determine whether there is a significant difference in mean weight loss among the three diets.

Plan	Weight Loss (lbs)				
A	8	9	6	10	7
B	4	5	6	5	4
C	10	12	9	11	13