

B. Perform testing of hypothesis using Two-way ANOVA.

A two-way ANOVA (“analysis of variance”) is used to determine whether or not there is a statistically significant difference between the means of three or more independent groups that have been split on two variables (sometimes called “factors”).

The results of a two-way ANOVA to be valid, the following assumptions should be met:

- **Normality** – The response variable is approximately normally distributed for each group.
- **Equal Variances** – The variances for each group should be roughly equal.
- **Independence** – The observations in each group are independent of each other and the observations within groups were obtained by a random sample.

Example:

A botanist wants to know whether plant growth is influenced by sunlight exposure and watering frequency. She plants 40 seeds and lets grow for two months under different conditions for sunlight

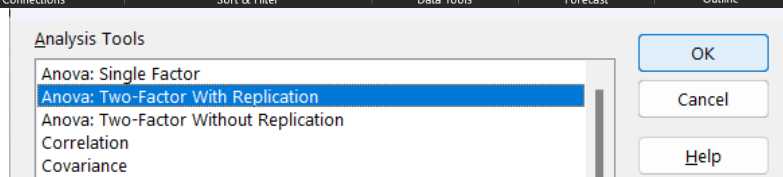
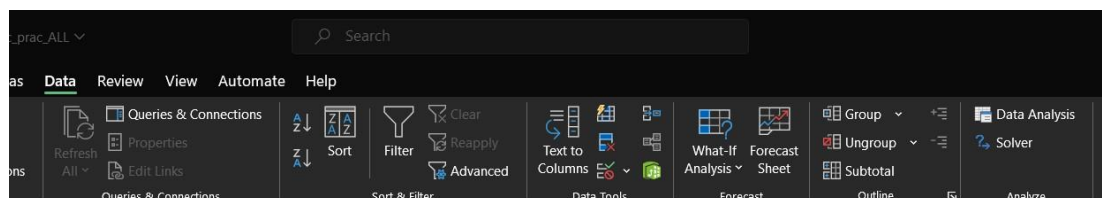
exposure and watering frequency. After two months, she records the height of each plant. The results are shown below:

| Water Frequency | Sunlight Exposure | | | |
|-----------------|-------------------|-----|--------|------|
| | None | Low | Medium | High |
| Daily | 4.8 | 5 | 6.4 | 6.3 |
| | 4.4 | 5.2 | 6.2 | 6.4 |
| | 3.2 | 5.6 | 4.7 | 5.6 |
| | 3.9 | 4.3 | 5.5 | 4.8 |
| | 4.4 | 4.8 | 5.8 | 5.8 |
| Weekly | 4.4 | 4.9 | 5.8 | 6 |
| | 4.2 | 5.3 | 6.2 | 4.9 |
| | 3.8 | 5.7 | 6.3 | 4.6 |
| | 3.7 | 5.4 | 6.5 | 5.6 |
| | 3.9 | 4.8 | 5.5 | 5.5 |

H₀ represents whether a plant watered daily or weekly has impact on how sunlight exposure affects a plant.

H₁ represents whether a plant watered daily or weekly has no impact, how sunlight exposure affects a plant.

Go to Data tab > Data Analysis



Anova: Two-Factor With Replication

Input Range:

Rows per sample:

Alpha:

Output options:

☒ Output Range:

☐ New Worksheet Ply:

☐ New Workbook

Input Range - A2:E12
Rows Per Sample – 5
Alpha – 0.05
Output Range - G1

| Anova: Two-Factor With Replication | | | | | | |
|------------------------------------|---------------|-----------|-----------|----------|----------------|---------------|
| SUMMARY | none | low | medium | high | Total | |
| | <i>daily</i> | | | | | |
| Count | 5 | 5 | 5 | 5 | 20 | |
| Sum | 20.7 | 24.9 | 28.6 | 28.9 | 103.1 | |
| Average | 4.14 | 4.98 | 5.72 | 5.78 | 5.155 | |
| Variance | 0.378 | 0.232 | 0.447 | 0.412 | 0.775237 | |
| | <i>weekly</i> | | | | | |
| Count | 5 | 5 | 5 | 5 | 20 | |
| Sum | 20 | 26.1 | 30.3 | 26.6 | 103 | |
| Average | 4 | 5.22 | 6.06 | 5.32 | 5.15 | |
| Variance | 0.085 | 0.137 | 0.163 | 0.317 | 0.722632 | |
| | <i>Total</i> | | | | | |
| Count | 10 | 10 | 10 | 10 | | |
| Sum | 40.7 | 51 | 58.9 | 55.5 | | |
| Average | 4.07 | 5.1 | 5.89 | 5.55 | | |
| Variance | 0.211222 | 0.18 | 0.303222 | 0.382778 | | |
| ANOVA | | | | | | |
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Sample | 0.00025 | 1 | 0.00025 | 0.000921 | 0.975975 | 4.149097 |
| Columns | 18.76475 | 3 | 6.254917 | 23.04898 | 3.9E-08 | 2.90112 |
| Interaction | 1.01075 | 3 | 0.336917 | 1.241517 | 0.310898 | 2.90112 |
| Within | 8.684 | 32 | 0.271375 | | | |
| Total | 28.45975 | 39 | | | | |

To take a decision, click on cell B15 and type==IF(L24<B14,"H0 accepted","H1 accepted,H0 rejected")

Output:

| | A | B | C | D | E |
|----|--------------------|--------------------------|-----|--------|------|
| 1 | | sunlight exposure | | | |
| 2 | water frequency | none | low | medium | high |
| 3 | daily | 4.8 | 5 | 6.4 | 6.3 |
| 4 | | 4.4 | 5.2 | 6.2 | 6.4 |
| 5 | | 3.2 | 5.6 | 4.7 | 5.6 |
| 6 | | 3.9 | 4.3 | 5.5 | 4.8 |
| 7 | | 4.4 | 4.8 | 5.8 | 5.8 |
| 8 | weekly | 4.4 | 4.9 | 5.8 | 6 |
| 9 | | 4.2 | 5.3 | 6.2 | 4.9 |
| 10 | | 3.8 | 5.7 | 6.3 | 4.6 |
| 11 | | 3.7 | 5.4 | 6.5 | 5.6 |
| 12 | | 3.9 | 4.8 | 5.5 | 5.5 |
| 13 | | | | | |
| 14 | significance level | 0.05 | | | |
| 15 | | H1 accepted, H0 rejected | | | |