**Problem 1:**

A research laboratory was developing a new compound for the relief of severe cases of hay fever. In an experiment with 36 volunteers, the amounts of the two active ingredients (A & B) in the compound were varied at three levels each. Randomization was used in assigning four volunteers to each of the nine treatments. The data on hours of relief can be found in the following .csv file: [Fever.csv](https://olympus.greatlearning.in/courses/13597/files/949141/download?verifier=Ow3glSgjJaj3kl7FbkgPsL4M7psv9Lmb8oDlWCSg&wrap=1)

[Assume all of the ANOVA assumptions are satisfied]

**1.1) State the Null and Alternate Hypothesis for conducting one-way ANOVA for both the variables ‘A’ and ‘B’ individually. [both statement and statistical form like Ho=mu, Ha>mu]**

For conducting one-way ANOVA for variable ‘A’:

The null hypothesis for A is that “the responses do not differ by the levels of factor A, while holding the levels of factor B constant and the interactions

The alternate hypothesis is that the responses differ by the levels of factor A, while holding the levels of factor B constant and the interactions

In statistical form,

Ho : mu1 = mu2 = mu3

Ha : all population means are not equal

Where mu1, mu2, mu3 are the population means of factor A

For conducting one-way ANOVA for variable ‘B’:

The null hypothesis for B is that “the responses do not differ by the levels of factor B, while holding the levels of factor A constant and the interactions

The alternate hypothesis is that the responses differ by the levels of factor B, while holding the levels of factor A constant and the interactions

In statistical form,

Ho : mu1 = mu2 = mu3

Ha : all population means are not equal

Where mu1, mu2, mu3 are the population means of factor B

1.2) Perform one-way ANOVA for variable ‘A’ with respect to the variable ‘Relief’. State whether the Null Hypothesis is accepted or rejected based on the ANOVA results.

By performing one-way ANOVA for variable ‘A’ with respect to the variable ‘Relief’, by using “model = ols(formula, data).fit()” , and by printing the anova table, we got the output

df sum\_sq mean\_sq F PR(>F)

Relief 1.0 13.604355 13.604355 44.494409 1.175871e-07

Residual 34.0 10.395645 0.305754 NaN NaN

Since p value < 0.05, we reject null hypothesis. That means the responses differ by the levels of factor A, while holding the levels of factor B constant and the interactions.

1.3) Perform one-way ANOVA for variable ‘B’ with respect to the variable ‘Relief’. State whether the Null Hypothesis is accepted or rejected based on the ANOVA results.

By performing one-way ANOVA for variable ‘B’ with respect to the variable ‘Relief’, by using “model = ols(formula, data).fit()” , and by printing the anova table, we got the output

df sum\_sq mean\_sq F PR(>F)

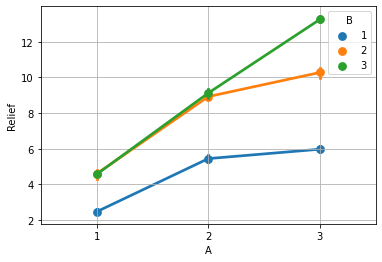
Relief 1.0 7.271475 7.271475 14.778958 0.000505

Residual 34.0 16.728525 0.492015 NaN NaN

Since p value < 0.05, we reject null hypothesis. That means the responses differ by the levels of factor B, while holding the levels of factor A constant and the interactions.

1.4) Analyze the effects of one variable on another with the help of an interaction plot.  
What is the interaction between the two treatments?  
[hint: use the ‘point plot’ function from the ‘seaborn’ function]

I have used point plot in seaborn to plot the interaction between the two treatments



The plot suggests that there is interaction between the levels of ingredient A and ingredient B because the distance between the means across the three levels are not the same.

1.5) Perform a two-way ANOVA based on the different ingredients (variable ‘A’ & ‘B’ along with their interaction 'A\*B') with the variable 'Relief' and state your results.

By performing two-way ANOVA based on variable ‘A’ & ‘B’ along with their interaction with the variable 'Relief', by using “model = ols('Relief ~ A+B+(A\*B)', data).fit()”, and by printing the anova table, we got the output

df sum\_sq mean\_sq F PR(>F)

A 1.0 212.415000 212.415000 308.976050 5.307332e-18

B 1.0 113.535000 113.535000 165.146510 3.529911e-14

A:B 1.0 26.780625 26.780625 38.954743 5.406597e-07

Residual 32.0 21.999375 0.687480 NaN NaN

The null hypothesis for the interaction is that “there is no interaction between the levels of ingredient A and ingredient B”. The alternative hypothesis is that “there is interaction”. The test statistic is F = 38.954743 and the p value is less than 0.05. Therefore, at the alpha level of 0.05, we reject the null hypothesis and conclude that there is significant interaction between the levels of ingredient A and ingredient B.

It is possible for the interaction to be significant when the main effects are not significant. So, lets test the significance of the main effects. The null hypothesis for the main effect for A is that “the responses do not differ by the levels of factor A, while holding constant the levels of factor B and the interactions”. The null hypothesis for the main effect for B is that “the responses do not differ by the levels of factor A, while holding constant the levels of factor A and the interactions”. The test statistics for the main effects A and B are F = 308.976050 and F = 165.146510, respectively. the p values are less than 0.05 for each. We reject the null hypothesis and conclude that the responses significantly differ across the levels of the two ingredients, while holding constant the other and the interactions.

1.6) Mention the business implications of performing ANOVA for this particular case study.

ANOVA performs the test of equality of more than two population means by actually analyzing the variance. Here by considering that all the assumptions of ANOVA are satisfied, we performed one-way and two-way ANOVA to know the interaction between the levels of ingredient A and ingredient B. At a confidence interval of 95%, we can conclude that there is significant interaction between the levels of ingredient A and ingredient B and also, we can conclude that the responses significantly differ across the levels of the two ingredients, while holding constant the other and the interactions.