Sample HW solution

Prob 3.10 [Optional problem statement here]

(a) Hypothesis: H_0: $\mu_1 = \mu_2 = \mu_3$

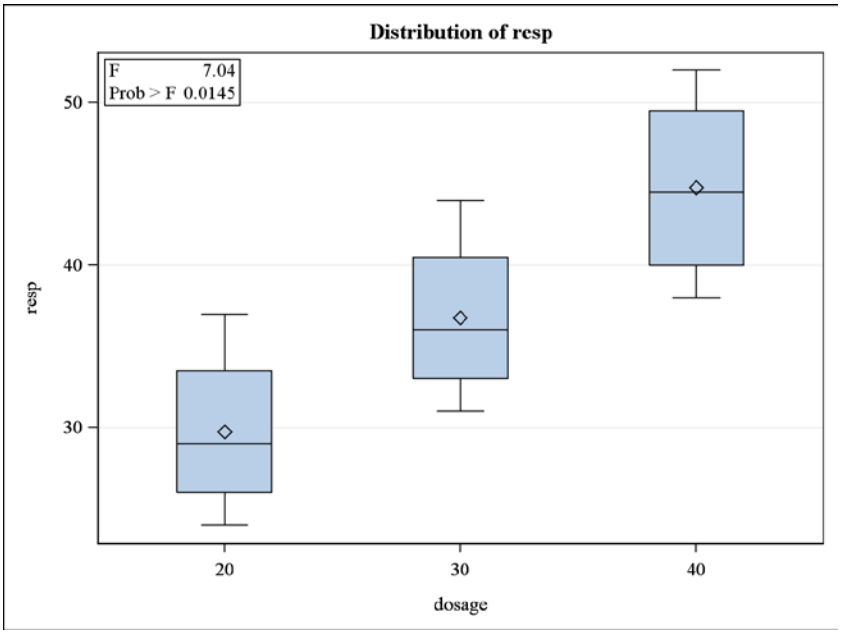
H_1: *at least one pair is not the same*

ANOVA table from SAS

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	450.6666667	225.3333333	7.04	0.0145
Error	9	288.2500000	32.0277778		
Corrected Total	11	738.9166667			

From the ANOVA table, since p-value is less than $\alpha = .05$, we reject the null hypothesis and conclude that there are significant difference in mean bioactivities among different dosage levels.

(b) As the hypothesis test in (a) shows significant effects on dosage, it is appropriate to do multiple comparisons. The box plot below shows that as dosage level increases the mean bioactivities increases and the mean differences looks quite visible.



We perform the Tukey's pairwise comparison. The result from SAS is as follows.

Alpha	0.05
Error Degrees of Freedom	9
Error Mean Square	32.02778
Critical Value of Studentized Range	3.94840
Minimum Significant Difference	11.173

Means with the same letter are not significantly different.				
Tukey Grouping		**Mean**	**N**	**dosage**
	A	44.750	4	40
	A			
B	A	36.750	4	30
B				
B		29.750	4	20

With 0.05 level of significance the MSD = 11.173. So if the absolute mean difference exceeds the MSD the means are significantly different.
The sample mean differences are

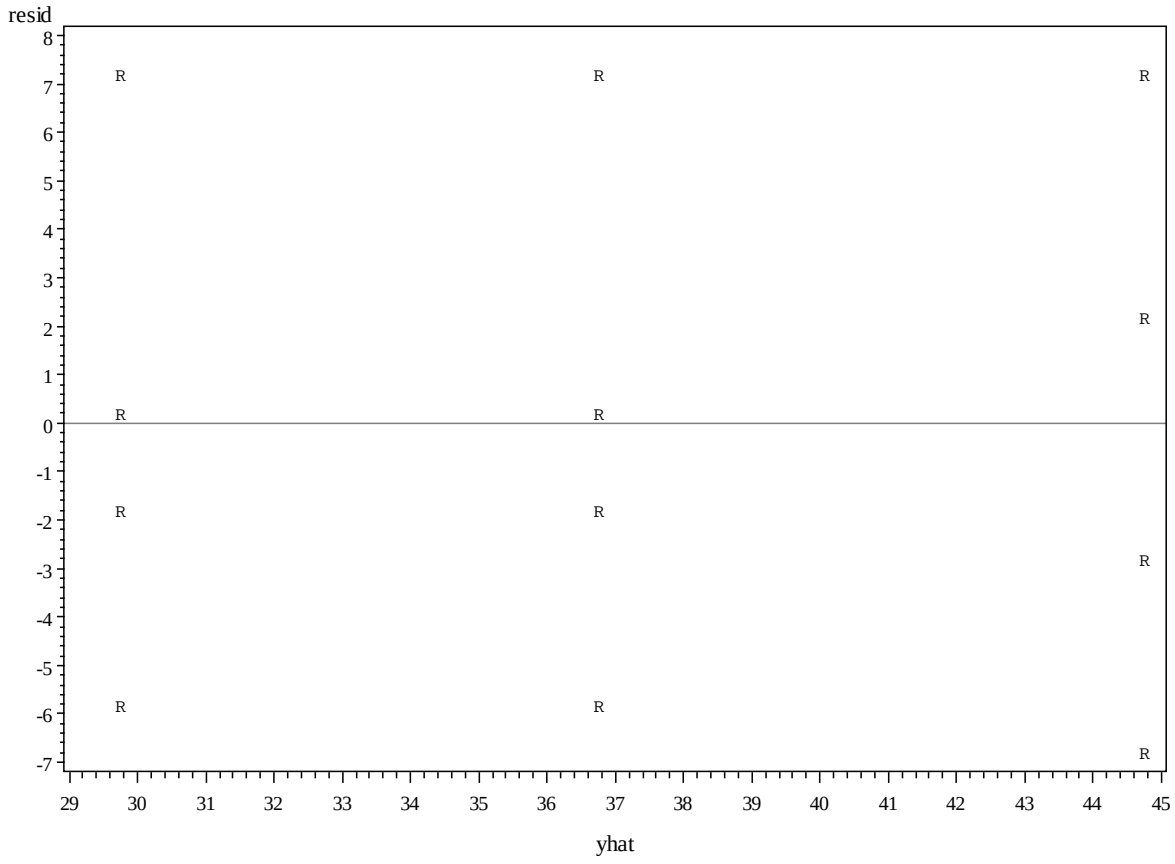
Dosage 20 vs 30: $|\bar{y}_1 - \bar{y}_2| = |29.75 - 36.75| = 7.0 < MSD$
Dosage 20 vs 40: $|\bar{y}_1 - \bar{y}_3| = |29.75 - 44.75| = 15.0 > MSD$ *
Dosage 30 vs 40: $|\bar{y}_2 - \bar{y}_3| = |36.75 - 44.75| = 8.0 < MSD$

The result shows that the mean bioactivity of dosage level 40 is significantly higher than that of dosage level 20. There is no significant difference between dosage level 20 and 30. It also shows that the mean bioactivity with the dosage level 30 does not differ significantly from the mean with the 40 dosage level.

(c) Residual analysis

The residual plot shows no indication of unequal variance. The high p-value of 0.9382 from the Levene's test also supports it. The normal probability plot shows the linearity and the p-value of .1435 from the Shapiro-Wilk test confirms the normality of the residual. Therefore, the normal and equal variances assumptions for the errors are valid.

Levene's Test for Homogeneity of resp Variance ANOVA of Squared Deviations from Group Means					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
dosage	2	80.6667	40.3333	0.06	0.9382
Error	9	5647.6	627.5		



Tests for Normality				
Test	**Statistic**		**p Value**	
Shapiro-Wilk	**W**	0.89663	**Pr < W**	0.1435
Kolmogorov-Smirnov	**D**	0.171654	**Pr > D**	>0.1500
Cramer-von Mises	**W-Sq**	0.057813	**Pr > W-Sq**	>0.2500
Anderson-Darling	**A-Sq**	0.457027	**Pr > A-Sq**	0.2250