```
    /* import data */

PROC IMPORT DATAFILE="/home/u63048916/STAT571B/Homework/Homework 3/Q4-36.csv"
    DBMS=CSV
    OUT=mont4_36
    REPLACE;
    GETNAMES=YES;
RUN;

proc glm data=mont4_36;
class Order Operator Workplace Method;
model Time = Order Operator Workplace Method;
output out=diag p=pred r=res;
means Method/ alpha=.05 lines tukey;
means Workplace/ alpha=.05 lines tukey;
run;


/* check normality */
proc univariate data=diag normal;
var res;
qqplot res / normal (mu=est sigma=est);
Run;


/* check outliers */
data outlier;
set diag;
stdres=res/3.027650;
run;

proc print data=outlier;
run;

/* check constant variance using graph*/
title 'residual plot: res vs predicted value ';
proc sgplot data=diag;
scatter x=pred y=res;
refline 0;
run;

title 'residual plot: res vs Order ';
proc sgplot data=diag;
scatter x=Order y=res;
refline 0;
run;

title 'residual plot: res vs Operator ';
proc sgplot data=diag;
scatter x=Operator y=res;
refline 0;
run;

title 'residual plot: res vs Method ';
proc sgplot data=diag;
scatter x=Method y=res;
refline 0;
run;

title 'residual plot: res vs Workplace ';
proc sgplot data=diag;
scatter x=Workplace y=res;
refline 0;
run;
```

4.36. Suppose that in Problem 4.23 the engineer suspects that the workplaces used by the four operators may represent an additional source of variation. A fourth factor, workplace (α, β, γ, δ) may be introduced and another experiment conducted, yielding the Graeco-Latin square that follows. Analyze the data from this experiment (use $\alpha = 0.05$) and draw conclusions.

Order of Assembly	Operator			
	1	2	3	4
1	$C\beta = 11$	$B\gamma = 10$	$D\delta = 14$	$A\alpha = 8$
2	$B\alpha = 8$	$C\delta = 12$	$A\gamma = 10$	$D\beta = 12$
3	$A\delta = 9$	$D\alpha = 11$	$B\beta = 7$	$C\gamma = 15$
4	$D\gamma = 9$	$A\beta = 8$	$C\alpha = 18$	$B\delta = 6$

Pairwise Treatment Comparison

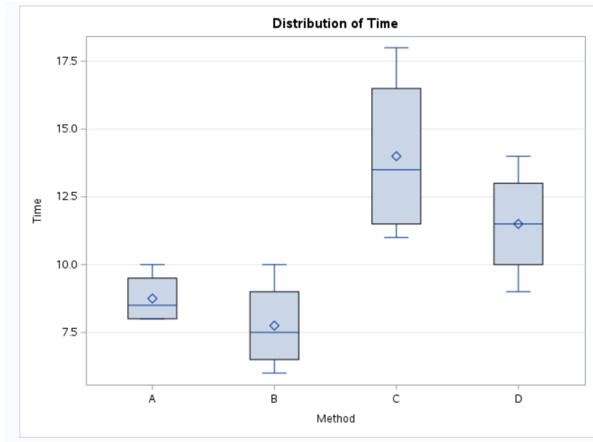

Figure 4.36.11

Alpha	0.05
Error Degrees of Freedom	3
Error Mean Square	9.166667
Critical Value of Studentized Range	6.82452
Minimum Significant Difference	10.331

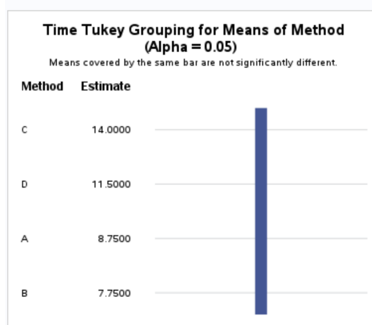

Figure 4.36.12

See Figure 4.36.2, the Type III P value for Method is 0.1669, so we cannot reject H_0 at an $\alpha = 0.05$ level with this information, and initially indicates that Method does not impact assembly time

$$H_0 : \tau_A = \tau_B = \tau_C = \tau_D = 0$$
$$H_a : \text{ at least one is different}$$

There are no outliers per Figure 4.36.5.

Normality diagnostics in 4.36.3 & .4 indicate that we do have issues with the normality of the residuals. All numerical diagnostics in 4.36.3 indicate significant non-normality characteristics, and the Q-Q plot Figure 4.36.4 shows a “step-like” non-linear pattern. Therefore we do not have valid assumptions to draw inferences from this model. A transformation of the data or another approach like nonparametric analysis would be necessary.

Residual plots and pairwise comparisons included as supplemental information, but cannot be used for inference due to the normality issues as described above.