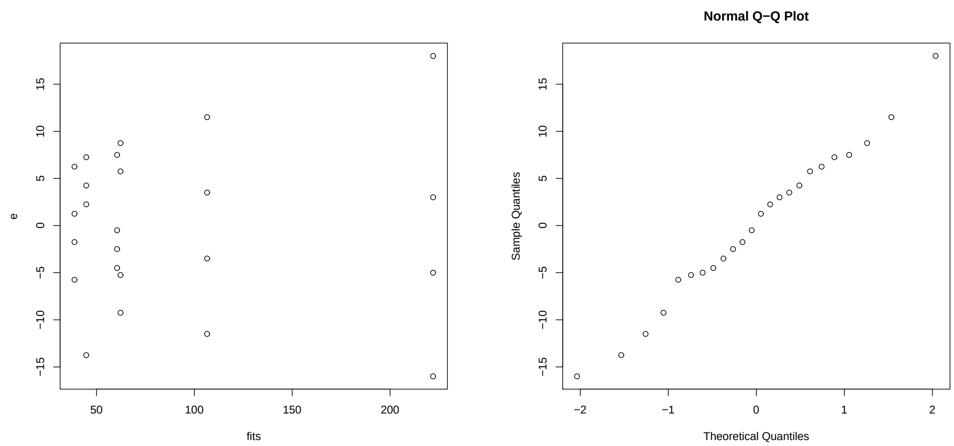
1. (a) The vertical spread seems reasonably consistent for each of the fitted values (six AB group means), so there is little evidence against the constant variance assumption.



(b) The plot (right side above) has a little curvature but overall follows a straight line. So, the normality assumption is reasonable as well.

(c) The ANOVA table below shows a test statistic of 117.07 with p-value approximately 0, which is strong evidence that the effect of Factor A depends on the level of Factor B (interaction).

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)
A	1	39447	39447	458.02	2.983e-14
B	2	36412	18206	211.39	3.158e-13
A:B	2	20165	10083	117.07	4.816e-11
Residuals	18	1550	86		

(d) The first two lines in the ANOVA table above test for the main effects for A and B, both of which are significant at the 0.01 level. However, since the test for main effects averages over the levels of the other factor, and the interaction means this effect is different depending on the level, it is probably not appropriate to test for main effects in this situation.

(e) Note, with only two levels of Factor A, no adjustment for multiplicity is actually needed here, and the usual t-critical value $qt(.975, 18) = 2.1$ would equal the Tukey value for two groups:

$$\frac{q(.95, 2, 18)}{\sqrt{2}} = 2.1.$$

The standard error for $\overline{Y}_{i\cdot\cdot} - \overline{Y}_{j\cdot\cdot}$ is

$$\sqrt{MSE\left(\frac{1}{bn} + \frac{1}{bn}\right)} = \sqrt{86\left(\frac{1}{12} + \frac{1}{12}\right)} = 3.79$$

The pair of means is declared significantly different since their difference $129.67 - 48.58$ exceeds $2.1(3.79) = 7.96$.

2. (a) The first figure represents a completely random design (CRD):

$$Y_{ij} = \mu_{\cdot} + \tau_j + \varepsilon_{ij},$$

and the second figure represents a randomized complete block design (RCBD):

$$Y_{ij} = \mu_{\cdot} + \rho_i + \tau_j + \varepsilon_{ij},$$

(b) In the CRD, the treatments are randomly assigned to all 24 pots equally, meaning any 6 pots could receive the first fertilizer, any 6 of the remaining pots could receive the second fertilizer, etc. In the RCBD, the randomization is restricted such that each treatment must occur once in each block.

(c) The partial ANOVA table is given by

```
Source     Df
Treatment   3
Block       5
Error      15
```

3. (a) The ANOVA table for this situation is

```
          Df  Sum Sq Mean Sq  F value    Pr(>F)
method     2 1295.00  647.50 103.7537 1.315e-10
block      9  433.37   48.15   7.7157 0.0001316
Residuals 18  112.33    6.24
```

(b) The hypotheses are $H_0 : \tau_1 = \tau_2 = \tau_3 = 0$, where τ_j is the effect of the jth teaching method. From the table above, the test statistic is 103.7537 with p-value approximately 0, which is significant evidence that the mean scores for the teaching methods are not all equal.

(c) The estimates for the mean teaching method scores are 70.6, 74.6, and 86.1, respectively, and the standard error for each difference is

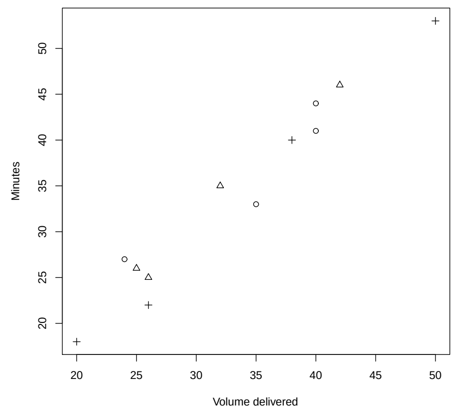
$$s\{\overline{Y}_{\cdot j} - \overline{Y}_{\cdot j'}\} = \sqrt{6.24\left(\frac{1}{10} + \frac{1}{10}\right)} = 1.117$$

Tukey's least significant difference is then

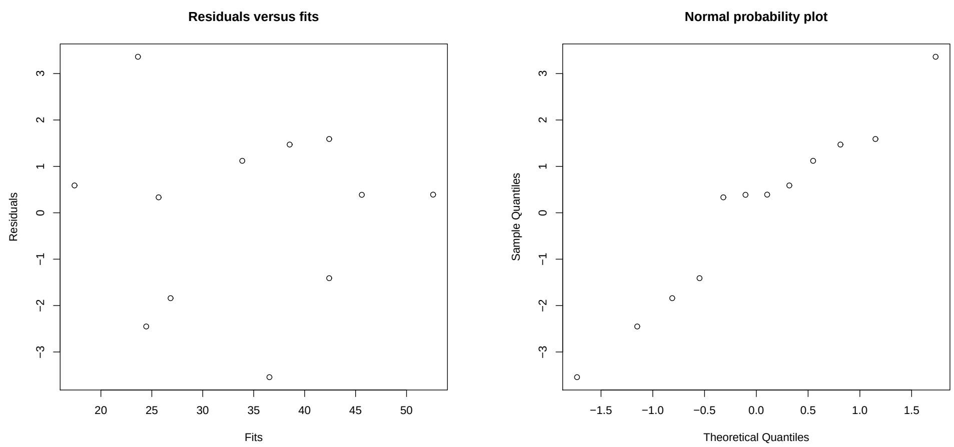
$$\frac{q(.95, 3, 18)}{\sqrt{2}} 1.117 = 2.85$$

By inspection, we see that all three teaching method group means are significantly different.

4. (a) There seems to be very little differences among the lines, both in terms of intercepts and slopes. So, we suspect that we don't need separate lines, but the significance will depend on the variability.



(b) Both plots show little evidence against the ANCOVA assumptions. The variance seems reasonably constant, and the normal plot seems nearly straight with the exception of a couple points.



(c) The reduced model is $Y_{ij} = \mu. + \gamma(X_{ij} - \overline{X}..) + \varepsilon_{ij}$ for $H_0 : \tau_1 = \tau_2 = \tau_3 = 0$. The test statistic is

$$\frac{(53.59 - 41.95)}{(10 - 8)} \Big/ \frac{41.95}{8} = 1.11$$

with 2 and 8 degrees of freedom. The p-value is .3735, which is not significant evidence to reject H_0. We cannot claim an effect due to truck type.

(d) The reduced model is $Y_{ij} = \mu. + \tau_i + \varepsilon_{ij}$ for $H_0 : \gamma = 0$. The test statistic is

$$\frac{(1259.50 - 41.95)}{(9 - 8)} \Big/ \frac{41.95}{8} = 232.2$$

with 1 and 8 degrees freedom. The p-value is approximately 0, which is significant evidence of a linear relationship (nonzero slope).

(e) The full model is $Y_{ij} = \mu. + \tau_i + \gamma_i(X_{ij} - \overline{X}..) + \varepsilon_{ij}$, and with $H_0 : \gamma_1 = \gamma_2 = \gamma_3$, the reduced model is the same as the full model in part (b). The test statistic is

$$\frac{(41.95 - 32.42)}{(8 - 6)} \Big/ \frac{32.42}{6} = .88$$

with 2 and 6 degrees of freedom. The p-value is .4615, which is not significant.