1. (a) Type II Sums of Squares were used.

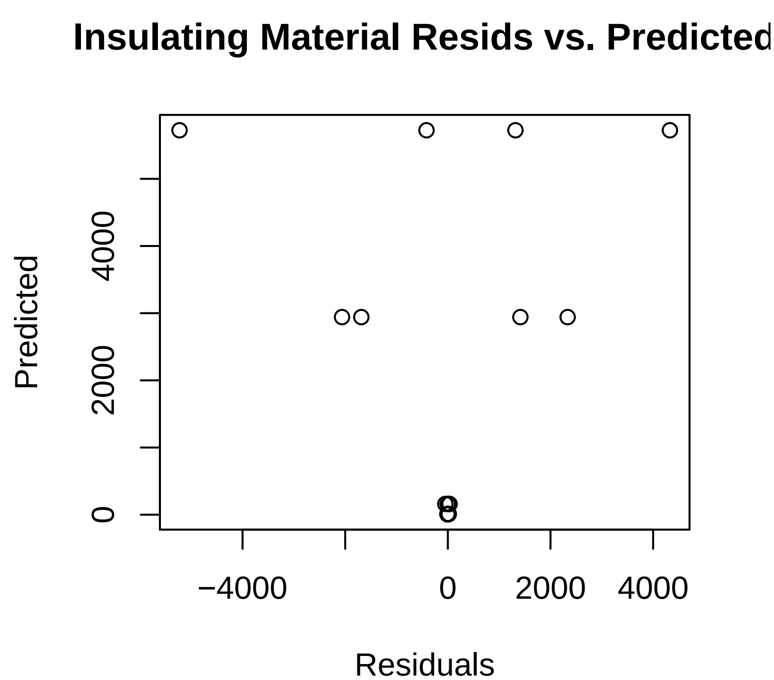
SSE	6.2505657×10^7
MSE	4.1670438×10^6
SS_{trt}	1.0319149×10^8
MS_{trt}	2.5797872×10^7
F-stat	6.190929
p-value	0.003786

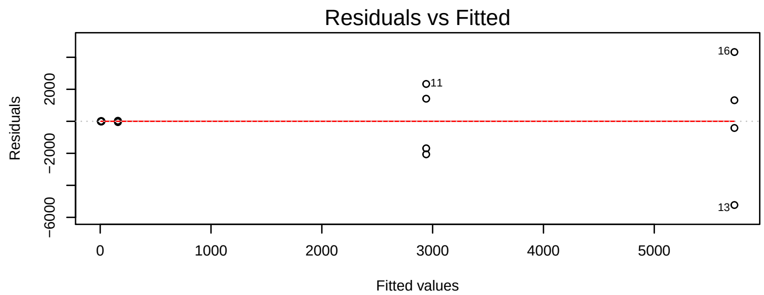
   (b) Let i and j index the 1-5 voltage levels.
   H_0: $\mu_i = \mu_j$ for all i $\neq$ j
   H_A: at least one $\mu_i \neq \mu_j$ for all i $\neq$ j

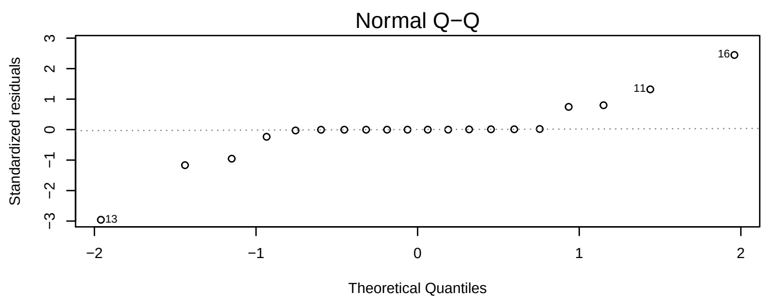
   (c) Below are the five sample variances.

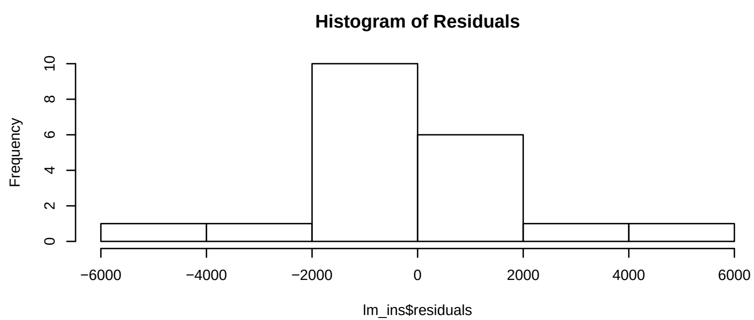
s_1^2	1329.58
s_2^2	62.92
s_3^2	4846188.25
s_4^2	15987486.00
s_5^2	152.25

   (d) Below are diagnostic plots.









The constant variance assumption is the most concerning violation, but the normal Q-Q plot also shows the tails of residuals are more extreme than would be expected under normality. Without correcting for the non-constant variance, the p-value from the F-test will be too small because there is extra variation we aren't accounting for, making us more likely to find evidence of significant differences that do not exist.

(e) The constant variance assumption violation is the most concerning, and without any more work, I would most likely not report these results. If I *were* to make a conclusion, it would be there is strong evidence the mean failure time differs between at least two voltage levels.

2. (a) Assume $\tau_2 = 0$.

$$X = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$$

$$X^T X = \begin{bmatrix} 12 & 4 & 4 \\ 4 & 4 & 0 \\ 4 & 0 & 4 \end{bmatrix}$$

$$(X^T X)^{-1} = \begin{bmatrix} 0.25 & -0.25 & -0.25 \\ -0.25 & 0.5 & 0.25 \\ -0.25 & 0.25 & 0.5 \end{bmatrix}$$

fix this – somethings wrong tapply(df$y, as.factor(df$**x),mean)**

$$X^T Y = \begin{bmatrix} 445 \\ 119 \\ 179 \end{bmatrix}$$

(b) $\theta = \begin{bmatrix} \mu \\ \theta_{dosage=20} \\ \theta_{dosage=40} \end{bmatrix}$

μ = the true mean observation for dosage 20

$\theta_{dosage=30}$ = the true change in mean observational units between the mean for dosage 20 and the mean for dosage 30

$\theta_{dosage=40}$ = the true change in mean observational units between the mean for dosage 20 and the mean for dosage 40

(c) $\hat{\theta} = \begin{bmatrix} 36.75 \\ -7 \\ 8 \end{bmatrix}$

(d) *Assume* $\Sigma\tau_i = 0$.

Let $\tau_3 = \tau_1 + \tau_2$

$$X = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 1 & -1 & -1 \\ 1 & -1 & -1 \\ 1 & -1 & -1 \\ 1 & -1 & -1 \end{bmatrix}$$

$$X^T X = \begin{bmatrix} 12 & 0 & 0 \\ 0 & 8 & 4 \\ 0 & 4 & 8 \end{bmatrix}$$

$$(X^T X)^{-1} = \begin{bmatrix} 0.083 & 0 & 0 \\ 0 & 0.167 & -0.083 \\ 0 & -0.83 & 0.167 \end{bmatrix}$$

$$X^T Y = \begin{bmatrix} 445 \\ -60 \\ -32 \end{bmatrix}$$

(e) $\theta = \begin{bmatrix} \mu \\ \theta_{dosage=30} \\ \theta_{dosage=40} \end{bmatrix}$

μ = the true mean observation over all dosages

$\theta_{dosage=30}$ = the true change in mean observational units between the overall mean and the mean for dosage 30

$\theta_{dosage=40}$ = the true change in mean observational units between the overall mean and the mean for dosage 40

(f) $\hat{\theta} = \begin{bmatrix} 37.0833333 \\ -7.3333333 \\ -0.3333333 \end{bmatrix}$

Remaining problems are attached.