

3)

Batch 1	23.46	23.59	23.51	23.28	23.29
Batch 2	23.48	23.46	23.64	23.40	23.46
Batch 3	23.56	23.42	23.46	23.37	23.37
Batch 4	23.39	23.49	23.52	23.46	23.32
Batch 5	23.40	23.50	23.49	23.39	23.38

a) Is this a random effect model? Why?

This is a random effect model. There is no deterministic decision made by the statistician in selecting the batches. If they were to take a bunch of batches from the right shift, this would be a fixed effect model where all records can only be translated to the results of right shift. With them being randomly selected, this is a random effect model.

b) Is there a significant variation in calcium content from batch to batch? Use  $\alpha = 0.05$ .

Source	SS	df	MS	F	p-value
Treatment	0.0698	4	0.02125	5.53	0.00363
Error	0.0876	20	0.00438		
Total	0.18458	24			

With a p-value less than 0.05, there is evidence to reject the null hypothesis that all the means are the same. There is evidence to suggest that at least one mean is different.

c) Estimate the variance components for this model.

$$\hat{\sigma}^2 = MS_E = 0.00438$$

$$\hat{\sigma}^2_T = MS_T - \frac{MS_E}{n} = 0.02125 - \frac{0.00438}{5} = 0.003974$$

$$Var[y_i] = 0.00438 + 0.02125 = 0.028605$$

$$SS_T = \frac{1}{n} \sum y_i^2 - \frac{(\sum y_i)^2}{N}$$

$$= \frac{1}{5} (68700.7825) - \frac{343501.481}{25}$$

$$= 13740.1565 - 13740.05952$$

$$= 0.09698$$

$$SS_{Tot} = \sum y_{ij}^2 - \frac{(\sum y_{ij})^2}{N}$$

$$= 13740.2441 - 13740.05952$$

$$= 0.18458$$