factors
level

chemist

1st   2nd   3rd   4th   One way Anova

1st	2nd	3rd	4th	Source	DF	SS	MS	F	P
84.99	85.15	84.72	84.20	treatment	3	1.045	0.348	3.25	0.081
84.04	85.13	84.48	84.10	error	8	0.858	0.107		
84.38	84.88	85.16	84.55						

1) The output above represents measurements of the percentage of methyl alcohol in a certain chemical compound. Each chemist made three determinations. Let μ_i denote the mean percentage of methyl alcohol for $i = 1, 2, 3$ and 4.

a) Find $\hat{\mu}_4$.

$$= \frac{84.2 + 84.1 + 84.55}{3} = \frac{252.85}{3}$$

$$= \boxed{84.2833}$$

b) Perform a 4 step Anova F test.

$H_0 \; \mu_1 = \mu_2 = \mu_3 = \mu_4$ H_A not H_0

$F_0 = 3.25$

pval $= 0.081$

fail to reject H_0, the mean percentage of methyl alcohol does not depend on the chemist

(factor level)

2) Suppose that the following 20 students have volunteered for an experiment that has 4 treatment levels A, B, C, and D: 1 Rahab, 2 Mona, 3 Craig, 4 Thomas, 5 Joseph, 6 Jazmin, 7 Mulubrahn, 8 Jason, 9 Sherri, 10 Philip, 11 Cody, 12 Sung-ho, 13 Lasanthi, 14 Dimuthu, 15 Hasthika, 16 James, 17 Jakob, 18 Patrick , 19 Alex, 20 Reginald. 5 students will get treatment A, 5 will get treatment B, 5 will get treatment C,a nd 5 will get treatment D. Use the following output to assign the treatments A and B to the students.

```
> sample(1:20)
[1] 20 16  4  7 13 2 10  5 15 18 17 19  6  1 12  3  8  9 14 11
```

A: Reginald, James, Thomas, Mulubrahn, Lasanthi

B: Mona, Philip, Joseph, Hasthika, Patrick

40

15

1

Source	df	SS	MS	F	P
treatment	4	0.096976	0.024244	5.535	0.0036
error	20	0.087600	0.004380		

3) Following Montgomerey (1984, p. 82), the response variable is the *calcium content* in a batch of material. Five measurements were made on each of five batches randomly selected from a population of batches. The researchers want to know if the calcium content depends on the batch.

factor { levels { }

a) State whether this is a random or fixed effects one way Anova. Explain briefly.

random effects since batches are randomly selected from a pop

b) Using the output above, perform the appropriate 4 step Anova F test.

$H_0 \ \sigma_\mu^2 = 0 \qquad H_A \ \sigma_\mu^2 > 0$

$F_0 = 5.535$

$pval = 0.0036$

reject H_0, $\sigma_\mu^2 > 0$, mean calcium content depends on batch

4) Sketch a good residual plot if there are 4 levels with $\overline{Y}_{10} = 2$, $\overline{Y}_{20} = 4$, $\overline{Y}_{30} = 6$, $\overline{Y}_{40} = 7$, and $n_i = 5$.

parallel dot plots with mean 0, same shape and spread