RECTIFICATION EXAM D2 AS 2020
Problem 1

Module:	**D2, Design and Analysis of Experiments**
Date of exam:	15.03.2021, 08:30-10:30 am
Duration:	2x 45 min
Type of exam:	Open book: Distributed printed course material allowed, personal notes allowed, laptop allowed, access to Internet allowed, pocket calculator allowed. Any form of oral or electronic communication with other students or persons from outside is forbidden. Furthermore, Videos and Screencasts are not allowed.
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School: *ZHAW*

Venue of exam: *online examination upload/download on Moodle*

Declaration of Independent Work

By taking part to this exam, I hereby affirm that the examination is my own work and that I have not used any sources other than those explicitly allowed for the exam. Furthermore, I have not assisted any other students with their online examination.

Exam Briefing

- Write your name and affiliation on the first page
- Next to each problem, the number of points is indicated in parentheses, e.g. (3). Partial credit can be accredited for partially correct answers.
- The level of significance is 5%. Give numeric results (such as p values) to at least three digits.
- Always include a short reasoning (e.g. I applied a marginal F-test and obtained a p value of … , and therefore I conclude ….“)
- **Report all your answers on this document. Convert it as a PDF file before submission.**

Best of luck!

Problem 1

Bacteria from the genus Ideonella can break down and consuming PET, which makes them very interesting from an environmental point of view to reduce plastic pollution.

One research group wants to investigate how bacterial growth is influenced by different growing conditions to be able to produce as much bacterial mass as possible to develop commercial applications.

To achieve this, they prepared independent Petri dishes with each the same amount of initial bacterial mass. The Petri dishes were randomly assigned to one (of two) growing conditions and stored in an incubator for 25 days. Due to organizational issues, several incubators were used. At the end of the growing period, all Petri dishes were weighted again, and the final weight was recorded.

The data set **growth_data** contains the results of the experiment:

- **final_g** indicates the final weight of bacterial mass in a Petri dish in g
- **cond** indicates the growing conditions applied
- **inc** indicates the incubator used

Set your working directory appropriately and import the data set using for e.g.:

```
mydata1 <- readRDS("growth_data.rds")
```

1. Give the **R** code to produce suitable descriptive statistics to describe the data set. (1)

```
str(mydata1)
summary(mydata1)
with(mydata1, tapply(final_g, cond, summary))
with(mydata1, tapply(final_g, cond, length))
```

A Randomized Design with factorial treatment structure is used. We use 60 observations in 2 groups with five repetitions (each incubator)

2. Give the **R** code to produce suitable graphical representations of the data set. What do you observe? (2)

```
library(ggplot2)
```

ggplot(mydata1, aes(y=final_g, x=inc))+geom_point()+ facet_grid(~cond)

We observe a systematically higher biomass weight in the growing conditions C1 than in C2. There is a significance seen between the incubators A and F. We can also see some differences and a positive linear relationship might be from incubator to incubator.

3. What is the main goal of the analysis and what does this imply for a possible incubator effect? Give the **R** code to fit a suitable parametric model to this data set. (2)

We want to asses the bacterial mass (final_g), while accounting for the growing conditions and incubators. We fit A model for factorial two-way ANOVA with replications - balanced design.

library(nlme)

mydata1.lm=lme(final_g~inc-1,random=~1|cond, data=mydata1) , -1 means excludes intercept since we do not have a control treatment.

4. Interpret your model: extract the estimated fixed effects and explain in your own words how to interpret them. (2)

fixef(mydata1.lm)

we see significant values in in all fixed effects of six incubators (A-F). because the p values are: 4.349069e-13, 1.633611e-14, 6.619248e-14, 4.556331e-15, 1.073718e-15, 4.257449e-17

we see that the equal variance is not guaranteed ant we can see that they are a incubator effect

5. Based on your model, what is the predicted average weight for bacterial mass under condition 2 in incubator D? Give the **R** code you used to compute the result. (1)

```
df = data.frame(final_g, cond="C2", data=mydata1)
df$pred = predict(mydata1.lm, df, level=0)
df
```

END of Problem 1