

5.4: Try It!

? Exercise 5.4.1: CO₂ Emissions

To study the variability in CO₂ emission rate by global regions 4 countries: US, Britain, India, and Australia were chosen. From each country, 3 major cities were chosen and the emission rates for each month for the year 2019 were collected.

1. What type of model is this?
 1. nested
 2. cross-nested
 3. factorial
2. How many factors?
 1. 4
 2. 3
 3. 2
3. The replicates are...
 1. 12 months of 2019
 2. countries US, Britain, India, and Australia
 3. major cities in US, Britain, India, and Australia
4. The residual effect in the ANOVA model is...
 1. country*city*month
 2. month(city(country))
 3. month(country*city)
5. How many degrees of freedom?
 1. 66
 2. 132
 3. 88

Show Answers and Explanations

Answers

Q1 - 1. nested

Q2 - 3. 2 factors

Q3 - 1. 12 months of 2019

Q4 - 2. month(city(country))

Q5 - 2. 132

Explanations

Residual effect (or error term) is the month(city(country)), which is the nested effect of "month", the replicate, within the combinations of the two factors "country" and "city". One way to double-check this answer is to verify if the df values are the same.

$$\begin{aligned}\text{error term df} &= \text{total df} - (\text{sum df values of the model terms}) \\ &= (144 - 1) - (\text{country df} + \text{city(country) df}) \\ &= 143 - (3 + 2 * 4) \\ &= 143 - 11 = 132\end{aligned}$$

$$\text{df for city(country)} = 11(12) = 132$$

See the [Section 5.2 ANOVA table](#) for df formula.

? Exercise 5.4.2

A military installation is interested in evaluating the speed of reloading a large gun. Two methods of reloading are considered, and 3 groups of cadets were evaluated (slight, average, and heavy individuals). Three teams were set up within each group and they wanted to identify the fastest team within each group to go on to a demonstration for the military officials. Each team performed the reloading with each method two times (two replications).

1. Identify (i.e. name) the treatment design.

1. nested
2. cross-nested
3. factorial

2. They started to construct the ANOVA table which is given below. Given that there are a total of 36 observations in the dataset, there seems to be a missing source of variation in the analysis. What is this source of variation?

Source	df
Method	1
Group	2
Method*Group	2
Team (Group)	6

1. Team*group*method
2. Team (Group)*method
3. Team*Group

3. How many degrees of freedom are associated with the error term?

1. 6
2. 24
3. 18

Show Answers

Q1 - 2. cross-nested

Q2 - 2. Team (Group)*method

Q3 - 3. 18

? Exercise 5.4.3: GPA Comparisons

The GPA comparison of four popular majors—biology, business, engineering, and psychology—between males and females is of interest. For 6 semesters, the average GPA of each of these majors for male and female students was computed.

1. What type of model is this?

1. nested
2. cross-nested
3. crossed

2. How many factors?

1. 4
2. 3
3. 2

3. The replicates are...

1. semesters
 2. majors
 3. gender
4. The residual effect in the ANOVA model is...
1. major*gender*semester
 2. semester(gender*major)
 3. semester(major(gender))
5. How many degrees of freedom?
1. 48
 2. 40
 3. 2

Show Answers and Explanations

Answers

Q1 - 3. crossed

Q2 - 3. 2 factors

Q3 - 1. semesters

Q4 - 2. semester(gender*major)

Q5 - 2. 40

Explanations

Residual effect (or error term) is semester (gender*major). The error term is the nested effect of "semester", the replicate nested within gender*major, which is the "combined effect" of the factors. One way to double-check is to verify if df values are the same.

$$\begin{aligned}\text{error term df} &= \text{total df} - (\text{sum df values of the model terms}) \\ &= (48 - 1) - (\text{major df} + \text{gender df} + \text{major*gender df}) \\ &= 47 - (3 + 1 + 3 * 1) \\ &= 40\end{aligned}$$

$$\text{df for semester(major*gender)} = 5 * 8 = 40$$

See the [Section 5.2](#) ANOVA table for df formula.

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