DEPARTMENT OF ECONOMICS AND BUSINESS ECONOMICS
AARHUS UNIVERSITY

EXAM ASSIGNMENT

Study Programme and level	MSc Operations and Supply Chain Analytics + elective	
Term	Winter 2024/25 – reexam	
Course name and exam code(s)	Tools for Analytics	460202E016
Exam form and duration	Written onsite exam, internet allowed	3 hours
Date and time	14 February 2025	9:00-12:00

Supplementary material/aids	All	X	Specified		No	
Anonymous exam	Yes	X	No		Please do **not** write your name or student ID number anywhere.	
Use of generative AI (GAI) allowed	Yes		No	X		
Hand-in of handwritten material allowed	Yes		No	X		
Hand-in of extra material (appendix) in WISEflow allowed	Yes	X	No			

Other relevant information	**Avoid being suspected of exam cheating** Remember to state references and use quotation marks, if you copy text from other sources or re-use parts of a previously submitted exam paper (plagiarism and self-plagiarism). Students must answer the exam assignment **individually**. All submitted exam papers are checked for plagiarism, so cheating and collaboration between students will be detected.
Number of pages (incl. front page)	6 pages

Other instructions:
It is important that you start uploading your exam paper well in advance - at least 10 min. before end of exam.

Practical information

- This exam is with internet. You may use any online or book-based resource you would like, but you must include citations for any code that you use (directly or indirectly). You may not consult with anyone else during this exam. That is, you cannot ask direct questions on the internet, use answers given on the internet after the start of this exam, or consult with each other, not even for hypothetical questions.

- The use of tools based on Generative AI, such as ChatGPT or Copilot, is not allowed.

- This assignment has an appendix available for download from WISEflow.

- Please note that the weights on each assignment are only guideline weights, and that they only provide information regarding the relative weight of the assignments. The final evaluation will be given based on the total material handed in.

- If you find that some information is missing in the assignments, you may make the necessary assumptions and clearly specify these.

- Handing in: You must hand in a set of files (`.Rmd` and `.html`) as "Appendix material". Due to the system, you must also upload an empty PDF document named `<participant index>.pdf`.

- Your R code will be tested using R version 4.4.2 (2024-10-31).

- Your R code must be written in an R Markdown (Rmd) file named `<participant index>.Rmd`. Moreover, hand in the rendered/knitted HTML file `<participant index>.html`.

- Your file must include your code and a (brief) comment for each question. For example, "The three companies with the smallest profit are . . . " or "The plot shows that . . . ".

- You may load and use the following packages:

```r
library(tidyverse)
library(skimr)
library(conflicted)
```

- An R markdown template file is given in the appendix on WISEflow that you may use as a starting point.

R - Assignment 1 (55%)

Given a company, consider the dataset in the file `mrp.csv` containing a Material Requirements Plan (MRP) for a group of materials. For each combination of week, material, and supplier, a row is given with information about inventory, requirements, etc.

The columns/variables are:

- `week`: Week number (consider weeks 8 to 30).
- `material_id`: Material id.
- `supplier_id`: Supplier id, i.e. the vendor the material is bought from.
- `supplier_desc`: Supplier description.
- `moq`: Minimum order quantity from supplier in units.
- `inventory_ini`: Initial inventory of the material in the start of week 8.
- `reqs`: Material requirements for the week. Note: inventory levels and requirements are given for fixed material and supplier.

The dataset can be read using:

```
library(tidyverse)
dat <- read_csv("mrp.csv")
```

Use the *dplyr* package in *tidyverse* to calculate relevant summary tables (tibbles/data frames), and answer/complete the following questions/tasks:

Question 1

How many different weeks, materials and suppliers are considered?

Question 2

Find the number of different materials required from each supplier. How many materials are required from the supplier with most different materials?

Question 3

For each material, calculate how many suppliers supply the specific material. How many suppliers sell material `M51136441`?

Question 4

Consider a material and a supplier. Note that the column `inventory_ini` contains the initial inventory level before the first week (week 8). Hence, for a row, the ultimo inventory level (end of week level) is calculated as the initial inventory level minus all the requirements up to and including the current week. Create a column `inventory_ultimo` with the ultimo inventory values. Hint: Given a group, the `cumsum` function can be used to add all values up to and including the current row.

Question 5

For each material, calculate the total requirements and ultimo inventory for each week. How many materials have a negative ultimo inventory in one of the weeks?

Question 6

A dataset with material info is given in the file `materials.csv`.

The columns/variables are:

- `material_id`: Material id.
- `material_desc`: Material description.
- `material_group_id`: Material group id.
- `marterial_group_desc`: Material group description.
- `abcd`: Inventory classification.

The dataset can be read using:

```r
dat_mat <- read_csv("materials.csv")
```

Answer the following questions:

- How many different materials are there in each inventory classification group?
- Does there exist material groups represented in more than one inventory classification group?
- Join the dataset with the MRP dataset. For each material group, calculate the number of suppliers, largest ultimo inventory in a week and the corresponding material used. Hint: To find the corresponding material, you have to create a second dataset and then join the results.

R - Assignment 2 (45%)

Answer this assignment using the *ggplot2* package in *tidyverse* (you may need *dplyr* for preparing the datasets you want to plot). Work with a slightly modified dataset from Assignment 1, which can be read using:

```
library(tidyverse)
dat <- read_csv("mrp-joined.csv")
```

The columns/variables are as mentioned in Assignment 1 except now all values have been summarized over all suppliers. Moreover, included is also this column/variable:

- `inventory_ultimo`: Ultimo inventory (end of the week) for the material.

Question 1

Create a visualization showing the number of materials in each material group with the following features:

- Bars are used for each material group ordered such that the height of the bars decreases over the x-axis.
- The material group description is shown at the x-axis (rotated 90 degrees).
- Informative figure title and axis titles are given.

Which material group has the highest number of materials?

Question 2

Create a visualization showing the total ultimo inventory for each material group with the following features:

- Lines are used for each material group. Hint: Using `geom_step` instead of `geom_line` may give a better visualization.
- Points are used to show data values. Moreover, the point color is used to identify if the ultimo inventory is negative. Hint: You need to define a new column with different values depending on whether the ultimo inventory is negative or positive.
- Line types are used to identify the material group.
- Informative figure title and axis titles are given.

Which material group has positive inventory in the last week?

Question 3

Consider materials with these ids:

```
mat_ids <- c("M51212503", "M51327609", "M51331501",
             "M51344118", "M51408045", "M51342678")
```

Create a visualization showing the variation of the weekly requirements for the 6 materials with the following features:

- A density is visualized for each material.
- Fill colors are used to identify the inventory classification.
- A plot is made for each material (facet).
- Legends are added at the bottom of the plot.

- Informative figure title and axis titles are given.

Consider the plots. Comment on the approximate value of the mean based on the plots.

Question 4

Negative inventories are unfavourable, and the company applies an ordering policy to get materials before negative inventories occur. Load the dataset with arrival orders using:

```
dat <- read_csv(file = "mrp-w-arrivals.csv")
```

New columns are:

- `inventory_primo`: the primo inventory (before arrival).
- `arrive_primo`: units that arrive primo in a week.

Moreover, the column `inventory_ultimo` contains updated values.

Create a visualization showing the total ultimo inventory in each inventory classification over the weeks with the following features:

- A line is used for each inventory classification.
- Colors are used to identify inventory classification.
- Legends are added at the bottom of the plot.
- Informative figure title and axis titles are given.

Which inventory classification has the highest inventory levels?

Question 5

Create a visualization showing the inventory levels over the weeks for material `M51331501` with the following features:

- Bars are used to visualize the requirements with a fixed blue fill color. Hint: You may use `width = 0.25` to make the width smaller.
- A line is used to visualize the inventory level before the requirements are satisfied, i.e. `inventory_primo + arrive_primo`.
- Points are used to visualize `inventory_primo + arrive_primo`. Use different colors depending on whether units arrive or not.
- Legends are added at the bottom of the plot.
- Informative figure title and axis titles are given.

How many times do units arrive?