Programming and Quantitative Skills 2025 Resit Solutions

Short-Answer Questions (4 points)

Question 1 (1 point)

Use R to calculate the following:

$$\frac{\frac{2}{3} + \log_2(9)}{\sqrt{2}}$$

Provide both the R command and numeric value in your answer.

Answer:

```
(2/3 + log(9, 2)) / sqrt(2)
```

```
[1] 2.71288
```

Question 2 (1 point)

Write an R command in the box below that generates a sequence of 10 evenly-spaced values starting from 0 and ending in 1.

The first two elements of your sequence should be 0.00000000 and 0.1111111.

Your answer must use a sequence-generating function. It is not permitted to write out the full vector manually.

Answer:

```
seq(from = 0, to = 1, length.out = 10)
```

```
 [1] 0.0000000 0.1111111 0.2222222 0.3333333 0.4444444 0.5555556 0.6666667
 [8] 0.7777778 0.8888889 1.0000000
```

Question 3 (1 points)

Consider the following two logical vectors:

```r
a <- c(TRUE, TRUE, FALSE, FALSE)
b <- c(TRUE, FALSE, TRUE, FALSE)
```

Write a one-line R command in the box below which returns a new logical vector where the elements are:

- `TRUE` when the corresponding element of `a` is `TRUE` *and* `b` is `FALSE`; and
- `FALSE` otherwise (i.e. when either `a` is `FALSE` *or* `b` is `TRUE`).

Your answer must use the variables `a` and `b` and the appropriate logical operators (a combination of a subset of the operators `&`, `|` and `!`).

Hint: The output of your command should be `[1] FALSE  TRUE FALSE FALSE`. The reason is because:

- Element 1 is `FALSE` because `b` is `TRUE`.
- Element 2 is `TRUE` because both `a` is `TRUE` *and* `b` is `FALSE`.
- Element 3 is `FALSE` because both `a` is `FALSE` *and* `b` is `TRUE`.
- Element 4 is `FALSE` because `a` is `FALSE`.

Answer:

```r
a & !b
```

```
[1] FALSE  TRUE FALSE FALSE
```

Question 4 (1 point)

Define the vector:

```r
x <- c(1, -1, 2, -2, 3, -3)
```

Write an R command in the box below using the `ifelse()` function that returns the absolute value of `x`.

The output of your command should be `[1] 1 1 2 2 3 3`.

Your answer must use the `ifelse()` function. Use of the `abs()` function is not permitted for this question.

Answer:

```r
ifelse(x > 0, x, -x)
```

```
[1] 1 1 2 2 3 3
```

Data Analysis (5 points)

Download the dataset sales-data-jan-2026.csv. The dataset contains information on the total sales of a fictitious firm from January 2026. The firm is a vintage record store chain. The store sells 3 types of products: cassette tapes, compact discs (CDs) and vinyl records. The chain has stores in 4 cities in Noord-Brabant

(Tilburg, Breda, 's-Hertogenbosch and Eindhoven). It charges the same price for each product type in each city: (€4.99 for a tape, €9.99 for a CD and €19.99 for a vinyl record).

The variable descriptions are:

- `product`: The product type (either `Tape`, `CD` or `Vinyl`).
- `city`: The city (either `Tilburg`, `Breda`, `'s-Hertogenbosch` or `Eindhoven`).
- `price`: The selling price of the product.
- `sales`: The total number of units sold of that product in that city in January 2026.

When reading the dataset into R, assign it to `df`.

Question 5 (1 point)

What is the median of the variable `sales`?

Provide both the numerical answer and the R command required to obtain the answer (if the dataframe is assigned to `df`).

Answer:

```
df <- read.csv("sales-data-jan-2026.csv")
median(df$sales)
```

```
[1] 124.5
```

Question 6 (2 points)

Part (a): Write an R command in the box below that creates a new variable in `df` called `revenue`, which is price multiplied by sales.

Answer:

```
df$revenue <- df$price * df$sales
```

Part (b): Write an R command in the box below that returns the total revenue of the firm from cassette tape sales.

Answer:

```
sum(df$revenue[df$product == "Tape"])
```

```
[1] 2664.66
```

Question 7 (1 points)

Write an R command in the box below using the `aggregate()` function that returns the total number of units sold by city.

The output of your command should be:

```
              city sales
1 's-Hertogenbosch   414
2            Breda   236
3        Eindhoven   390
4          Tilburg   362
```

Answer:

```
aggregate(sales ~ city, data = df, FUN = sum)
```

```
              city sales
1 's-Hertogenbosch   414
2            Breda   236
3        Eindhoven   390
4          Tilburg   362
```

Question 8 (1 points)

Using an appropriate function from the `reshape2` package, write an R command in the box below to reshape the data such that there are 4 rows, one for each city, and the columns are:

- The city.
- The sales of CDs in each city.
- The sales of cassette tapes in each city.
- The sales of vinyl records in each city.

The output should be the following:

```
              city  CD Tape Vinyl
1 's-Hertogenbosch 133  139   142
2            Breda  76  124    36
3        Eindhoven 149  124   117
4          Tilburg  90  147   125
```

Hint: Load the `reshape2` package using the command `library(reshape2)`. You do not need to include loading this package in your answer.

Answer:

```
library(reshape2)
dcast(df, city ~ product, value.var = "sales")
```

```
              city  CD Tape Vinyl
1 's-Hertogenbosch 133  139   142
2            Breda  76  124    36
3        Eindhoven 149  124   117
4          Tilburg  90  147   125
```

Data Cleaning (7 points)

Download the following dataset:

AHOLD DEL_historical_price.csv

The file was obtained from the website https://live.euronext.com/. It contains stock price data for the Dutch-Belgian multinational retail and wholesale holding company Ahold Delhaize, which owns the brands Albert Heijn, Etos, Gall & Gall and Bol.com, as well as several brands in other countries. The data spans the period January 2 to December 31 2025.

In order to analyze the data, some cleaning steps are required.

Question 9 (5 points)

Perform the data cleaning steps below:

Note: The data after each step should match the files below. If you cannot complete a step, you can use these to proceed. For example, if you cannot do part (a), use the file `resit-2025-q9a.csv` to attempt part (b).

- Data after part (a): resit-2025-q9a.csv
- Data after part (b): resit-2025-q9b.csv
- Data after part (c): resit-2025-q9c.csv
- Data after part (d): resit-2025-q9d.csv

Part (a): Write an R command in the box below to read the dataset into R as `df`. Use the `skip` argument in the `read.csv()` function to skip the lines of metadata at the top of the file, so that the data can be read in properly. The lines of metadata are the following:

```
"Historical Data"
"From 2025-01-02 to 2025-12-31"
NL0011794037
```

Answer:

```r
df <- read.csv("AHOLD DEL_historical_price.csv", skip = 3)
```

Part (b): Write an R command in the box below that will correctly format the `Date` variable to an R date.

Answer:

```r
df$Date <- as.Date(df$Date, format = "%d/%m/%Y")
```

Part (c): Write an R command in the box below that will sort the data by date ascending. That is, January 2 should be first and December 31 should be last.

Answer:

```
df <- df[order(df$Date), ]
```

Part (d): Write an R command in the box below that creates a variable called `spread` which is the `High` variable minus the `Low` variable. This variable measures the volatility of the stock in a day.

Answer:

```
df$spread <- df$High - df$Low
```

Part (e): Write an R command in the box below that will convert all the variable names to lower case.

Answer:

```
names(df) <- tolower(names(df))
```

Question 10 (1 point)

If you performed the data cleaning steps from the previous exercise correctly, your final dataset should match the following file: ahold-delhaize-2025.csv

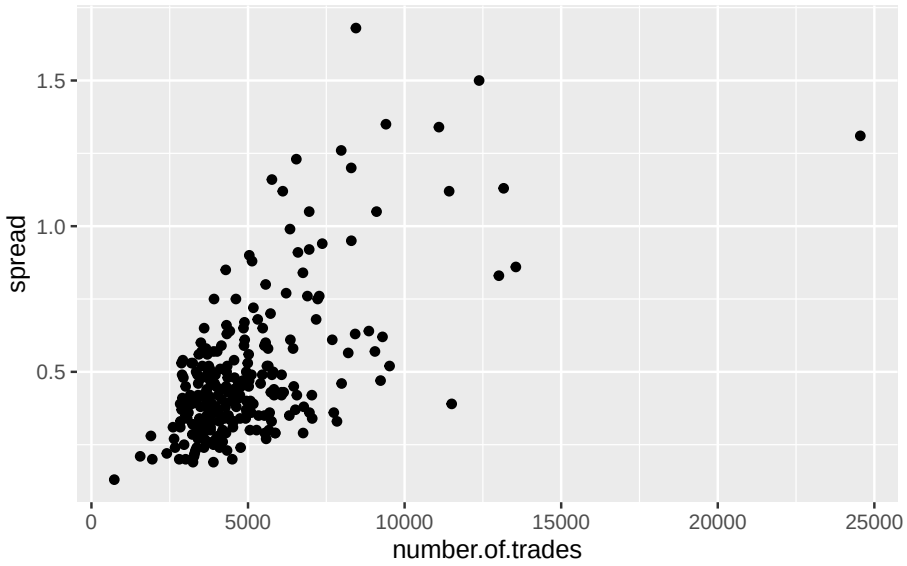
Using either your cleaned data or the data from the file above, create a scatter plot with `number.of.trades` on the horizontal axis and `spread` on the vertical axis.

Choose the answer below which best interprets what you see in the plot.

- When `number.of.trades` is high, `spread` is usually low.
- When `number.of.trades` is high, `spread` is usually also high.
- There does not appear to be any relationship between the variables `number.of.trades` and `spread`.
- When `number.of.trades` is at its highest or lowest, `spread` is at its highest, but for values of `number.of.trades` near the median, `spread` is at its lowest.

Answer:

```
library(ggplot2)
ggplot(df, aes(number.of.trades, spread)) + geom_point()
```




```
# When `number.of.trades` is high, `spread` is usually also high.
```

Question 11 (1 point)

Using the cleaned data, plot the variable `close` across time. In which quarter of the year was the variable `close` at its highest?

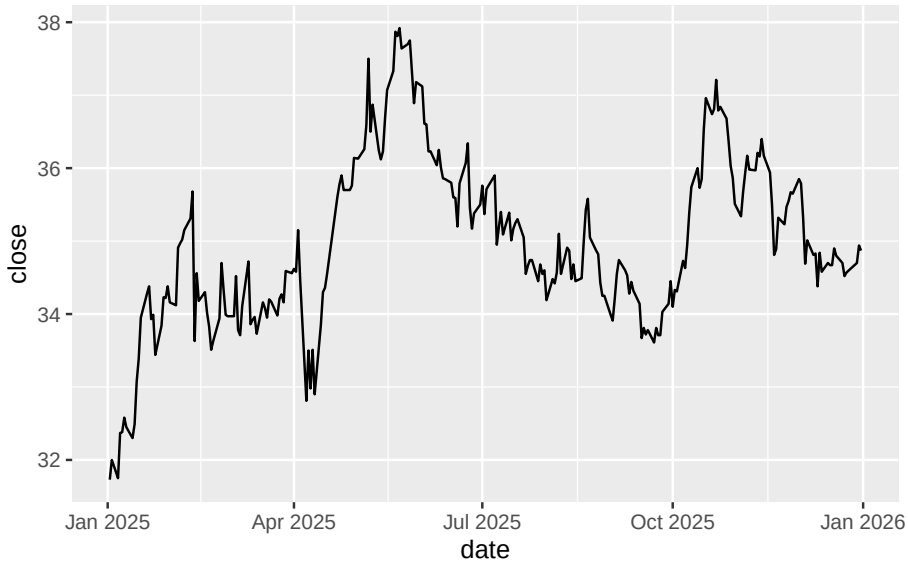
Type the quarter number in the box below, where:

- Quarter 1 is January-March.
- Quarter 2 is April-June.
- Quarter 3 is July-September.
- Quarter 4 is October-December.

Answer:

```
[1] "LC_CTYPE=C;LC_NUMERIC=C;LC_TIME=C;LC_COLLATE=C;LC_MONETARY=C;LC_MESSAGES=ga_IE.UTF-8;LC
```

```
library(ggplot2)
ggplot(df, aes(date, close)) + geom_line()
```




```
# The close variable is at its highest in Q2
```

Optimization (2 points)

The following 2 questions will involve working with the following mathematical function defined over all real numbers x:

$$f(x) = -10 - 4x + 2x^2$$

Question 12 (1 point)

Plot the function between the x values -3 and $+5$. Add the correct options in the boxes below that best describe the plot.

Part (a): The shape of the function is *a straight line / flat / U-shaped / inverse U-shaped*.

Part (b): When $f(x) = -10$, the corresponding values of x are _____ and _____.

Part (c): At $x = 4$, the function is *downward-sloping / flat / upward-sloping*.

Answer:

```
f <- function(x) {
  y <- -10 - 4*x + 2 * x^2
  return(y)
}
library(ggplot2)
x <- seq(-3, 5, length.out = 2000)
```

```
y <- f(x)
df <- data.frame(x, y)
ggplot(df, aes(x, y)) + geom_line()
```


```
# Part (a) The shape of the function is U-shaped.
# Part (b) The values of x when f(x)=-10 are 0 and 2.
# Part (c) At x=4, the function is upward-sloping.
```

Question 13 (1 point)

Use R to find the value of x at an extreme point of this function.

Part (a) Type this value of x in the box below.

Answer:

```
f_min <- optimize(f, c(-100, 100), maximum = FALSE)
f_min$minimum
```

```
[1] 1
```

Part (b): What value does the function take at the extreme point?

Answer:

```
f_min$objective
```

```
[1] -12
```

```r
# or alternatively:
f(f_min$minimum)
```

```
[1] -12
```