Information

Instructions: Please read carefully

The following instructions apply to all CodeRunner questions.

1. Into the space provided, write R code that (ultimately) assigns to each of these variables the answer to the question.
   - You may either implement your answer in the space provided, or you may work elsewhere, and only provide your final answers as constants.
   - Note that not all R packages may be available in the testing environment.
2. Click "Precheck" to check that your answers are formatted correctly, and address any issues.
   - Passing tests get marked with ✔, failing tests with ✘.
   - **IMPORTANT:** If your code fails the first pre-check (i.e., code produces errors when executing), your assessment **cannot** be marked, and you may receive 0 **for the whole question**.
3. The code will be submitted when you submit the quiz.
4. When you submit the quiz, you **may** get a weird error message along the lines of "Expected 0 test results, got 1." Please disregard it.

Cluster Analysis

Note: The additional R packages relevant for this exercise *are* available on the system.

Suppose that we observe a sample $\boldsymbol{X}_i \in \mathbb{R}^8$ for $i = 1, \ldots, 89$. The sample (with observations in rows) can be constructed by the following R code:

```
X <- matrix(c(-3.4, 3.9, 3.9, 3.9, 2, -1.2, 1.7, 1, -3.7, -1.7, 4.5, 0.2, 0.2, 0.7, -1.9, 0.7, 3.6, -0.6,
-0.4, 2.9, -0.5, 2.1, 0.2, 5.3, -3.8, -2.1, 4.5, -1.6, 3, -3.8, -4.8, 2.4, -1.1, 0, 0, 0.5, 1.6, 3.4, 3.6,
2.6, -1.2, -0.5, -0.2, 3.1, 0.4, -3.9, 3.3, 3.5, -1.2, -0.4, 0.9, 1.4, 1, -1.8, -0.5, 4.5, -3.8, -1.8, 5, 1.3,
3.5, -2.7, 1.2, 1.1, -0.3, -0.4, -2.2, -3.8, -3.7, 2.6, 1.7, -1.3, -3.9, -2.9, 3.2, -1.7, 1.9, 0.3, -6.1, 0.5,
0.2, 0.2, 0.1, -0.2, 0.1, -6.6, -3.7, 2.6, -3.7, -1.4, 4.1, 0.6, 2.5, -1.1, 1.1, 2.3, -1.1, 0.1, 1.6, -3.1,
3.5, -3.9, 0.9, 3, 0, -0.5, 0.4, -2, 7, -4.2, -5.8, 1.3, -0.2, 0.2, -2.4, -4.3, -3.1, 2, 4.3, -4.2, -0.1,
-0.9, -0.7, 2.3, 7.2, -3.3, -0.5, 0.1, -3.5, 3.5, 3.7, 3, 2.4, -3.2, -0.5, 3.1, -3.6, 2.6, 1.6, 3.7, 3.8, 0.2,
0.2, 2.4, -0.3, -0.9, -3.2, -2.8, -2.9, -1.7, -4.6, -1.9, -3.9, -2.7, 4.3, -0.7, 3.6, -2.7, -4.2, 2.3, 3.9,
1.6, 1.8, -0.2, -0.7, -1.7, 5.1, 4.7, -0.2, -0.3, -2.2, -6.3, -5.2, 2.2, -3, -3.8, 0.2, 0.2, 0, -3.1, 2, -0.5,
-3.3, -0.5, 0.1, -0.3, -1.1, -1.8, 5.9, 2.3, 0.5, -1.2, -0.4, -1.1, -3.5, 0, -0.9, 2.8, 0.8, -0.1, -3.5, 3.3,
3, 4.6, 4.1, -2.6, 2.5, 1.5, -1.2, -0.1, 1, 0.4, 2.2, -2.6, 2, 2.9, 4, 1.7, 2, -2, 0, 0.2, 3.8, 1.1, -0.4,
-0.9, -3.2, -1.5, -3.8, -0.1, -3.8, -2.7, -1, 0.6, 0.8, -0.3, 1.9, -2.5, 1.6, 0.9, -3.8, -2.2, 4, -0.6, 1.6,
-1.6, -3.2, 1.8, -0.4, -1.6, -3.7, -1.6, -4.3, 3.1, -5.6, 2.6, -1.1, 0, 1.1, 0.9, 0.2, -1.8, -0.7, 2.8, 3.9,
1, 0.1, 3, -2.4, -2.5, 3.1, 6.4, -3.4, 3.8, 2.6, 3.5, 1.4, -1, 2.3, 1.6, -0.4, -1.3, -4.1, -0.6, -3.7, 2.5,
-3, -2.1, -3.4, 3.4, 2.4, 3.7, -0.2, 1, -1.1, 3.1, -3.5, 3.3, 2.8, 3.7, 2.1, -1.6, 0.1, 1, 3.7, 0.2, 0.1, 1.8,
0.1, -3.9, 3.3, 1.5, 0.1, -0.3, -0.8, -1.5, 6.3, -3.3, 0.4, 0.3, 3.9, 0.6, -0.5, 0.9, -1.6, 2.2, 3.5, 3.9,
-3.3, 4.4, 3, 2, 1.9, 0.2, 3.2, 0.7, -3.4, 3.9, 2.6, 5.9, 3.1, -1.6, 1.3, 3.2, -3.8, -2.1, 4.4, 0.2, 1.5,
-2.6, -2.8, 0.4, -3.8, -2.4, 4, 1.1, 2.4, -2.4, -4, 2.5, -0.4, -0.8, -3.1, 1.2, -1.5, -3.9, 1, 0.5, -1, 0.2,
0.6, 0.8, -0.2, 0.9, 0.9, 4, -3.4, 3.5, 2.4, 3, 2.5, 0.7, 0.7, 2.4, 0.2, 0.3, -1.3, 0.9, 4.2, -1.5, 3.7, -0.7,
-1.1, 0, 0.7, 0, 1.2, -0.4, -3.1, 1.9, -3.5, 3.4, 2.8, 4.9, 3.7, -1.2, 3.9, 2.1, -3.8, -1.8, 5.5, -2.8, 3,
-3.1, -4.5, 1, -0.4, -1, -3, -1.6, -0.7, -3.2, -0.9, -1, -1.2, -0.5, 0, -0.1, 1.5, 1.1, 1.5, 2.7, -3.5, 3.6,
3.2, 1, 1.5, -0.1, -2.8, -1.7, -3.6, 2.8, 3.3, 3.7, 5.3, -2.3, -2.2, 2.1, 0, -0.1, 0.2, 0.7, 3.8, -3.6, -2.3,
0.2, 3.7, -0.1, -1, 2.8, 0.8, 0.6, 3.5, 6.6, -3.6, 2.7, 2.5, 2.6, 4.1, -0.6, -4.5, 1.9, 0.2, 0, -1.5, -1.8,
1.8, -1.2, -2.2, -0.9, -1.1, 0.2, 1, -2, 0.5, 2, 1.1, 1.3, -3.5, 3.2, 2.2, 7.1, 3.8, -1.2, 0.8, 1.7, -3.7,
-1.9, 4.2, 0.1, 3.4, -2.6, -3.1, 2.9, 3.9, 0.7, 0.1, 0.7, 2.9, -0.7, 4.4, 5.5, -3.4, 4.3, 4.4, 0.8, 1, 1, 2.7,
1.1, 0.1, -0.2, -1.3, 0.3, 4.5, -1.4, 3.2, 0.9, -3.4, 3.6, 2.5, 3, 2.6, 0.1, 4.5, -0.9, -0.3, -0.6, -2.9,
-3.7, -3.7, -2.6, -2.4, -2, 0.2, 0.7, 0.2, -5.5, 4.4, -1.6, 2, -2.1, 0, -0.8, -0.9, -3.9, 4.7, -0.3, -3.2,
-0.7, -1, 0.4, -0.1, -3.5, 3.7, 0.7, 5.1, 0.5, -3.5, 3.5, 4, 3.4, 3.2, -2.5, 2.1, 1, -1, 0.1, -0.1, -1.4, 2.3,
0.1, 2.7, 3.7, -3.8, -2, 4.1, 0.3, 0.6, -2.4, -1.6, 2.3, -0.4, -2, -4.7, -3.4, -0.5, 6.6, -2.4, 0.5, 4, 1.2,
-0.4, -1.2, -1.2, -1.4, 1.6, 1.5, -3.9, -2.4, 4.6, 0.5, 3.5, -2.7, -2.8, 2.9, -3.5, 3.3, 2.9, 5.1, 0.9, -1.3,
-0.2, 2, -0.3, -0.9, -3.5, -1.2, -1.3, -3.9, -6.9, 1.8, -3.8, -2.3, 3.7, 0.6, 2.9, -3.6, -2.9, 3.2, 4, 1.2,
-0.1, -0.2, -0.4, -3.3, 0.5, 5.4, 0.1, -0.4, -0.6, -3.3, 3.4, -2.5, -3.9, 1.7, -3.8, -2.3, 4.3, -0.7, 3.5,
-1.8, -5.5, 1.1, -1.1, 0, -0.2, -0.3, 0.8, 2.8, 0.9, 2.2, -0.1, -0.8, 0.2, -0.5, 5.2, -5.5, -3.2, -0.4, -0.1,
-1.2, -1, -1.6, 3.8, 1.3, -2.3, 2.1, -3.9, -2.3, 4.6, 2.4, 0.6, -3.3, -6.3, 3.2, -0.1, -1, -0.8, -2.5, 4.2,
-3.3, -2.6, 1.3, -0.4, -1, -2.4, -3.8, -2.1, -2.6, 1, -3.3), 89, 8, byrow=TRUE)
```

If you wish to convert them to a data frame and/or save them to a file, the following code might be helpful:

```
write.csv(as.data.frame(X), "X.csv", row.names=FALSE)
```

(a)

Cluster these data using model-based clustering, and save the result of the fit in variable `ans_a_fit` . Store the estimated number of clusters in variable `ans_a_K`.

(b)

Suppose that we know that there are actually 2 groups in the data. Does the best model-based cluster model have varying orientations? Store the fit in variable `ans_b_fit`, and store the the answer in `ans_b_o` (`TRUE` for Yes, `FALSE` for No).

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```
2
3  ans_a_fit <-
4
5  ans_a_K <-
6
7  ans_b_fit <-
8
9  ans_b_o <-
10
```

Precheck

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