**Solution Exercises Step by Step**

An appendix to the thesis submitted in partial

fulfillment of the requirement for the award of the

Bachelor’s Degree of Mechanical Engineering with Honours

Faculty of Mechanical and Manufacturing Engineering

Universiti Tun Hussein Onn Malaysia

July 2023

**Abstract**

This document is an English explanation on how to solve the Learning Factory. Each of the exercises has a chapter where answers are provided step by step. Solutions are provided in the following format: On the left-hand side figures show illustrate the steps. On the right-hand side the reader can find instructions.

CONTENTS

[CHAPTER 1 Glossary 1](#_Toc138863485)

[CHAPTER 2 Exercise 1 2](#_Toc138863486)

[CHAPTER 3 Exercise 2 4](#_Toc138863487)

[CHAPTER 4 Exercise 3 6](#_Toc138863488)

[CHAPTER 5 Exercise 4 7](#_Toc138863489)

[CHAPTER 6 Exercise 5 9](#_Toc138863490)

[CHAPTER 7 Exercise 7 13](#_Toc138863491)

# Glossary

|  |  |
| --- | --- |
| German | English |
| Lern | Learn |
| Fabrik | Factory |
| Lernfabrik | Learning factory |
| Aktuell | Current |
| Künstliche Intelligenz / KI | Artificial Intelligence / AI |
| Modul | Module |
| Modell | Model |

# Exercise 1

|  |  |
| --- | --- |
| [hivemqserver.feste-ip.net:9443/nifi/](https://learn.ki-campus.org/go/link?url=https%3A%2F%2Fhivemqserver.feste-ip.net%3A9443%2Fnifi%2F&checksum=66f7638&tracking_type=rich_text_item_link&tracking_id=2054f950-1cac-49a9-9da3-46d916ab54d0&tracking_course_id=bc88ac00-0c8c-4019-bacc-bf7bac0abbdf) | Open link to nifi page |
|  | Insert the following credentials:  user: lernfabrik  pw: L5nf1br|k  Now you can take a look |
| [hivemqserver.feste-ip.net:9001](https://learn.ki-campus.org/go/link?url=https%3A%2F%2Fhivemqserver.feste-ip.net%3A9001%2Fhub%2Flogin&checksum=43e3f83&tracking_type=rich_text_item_link&tracking_id=2054f950-1cac-49a9-9da3-46d916ab54d0&tracking_course_id=bc88ac00-0c8c-4019-bacc-bf7bac0abbdf) | Open the link to access Jupyter |
|  | Insert the following credentials:  user: lernfabrik  pw: L5nf1br|k  From here you can open new terminals and view the used notebooks |
| [hivemqserver.feste-ip.net:1880](https://learn.ki-campus.org/go/link?url=https%3A%2F%2Fhivemqserver.feste-ip.net%3A1880&checksum=615a39d&tracking_type=rich_text_item_link&tracking_id=2054f950-1cac-49a9-9da3-46d916ab54d0&tracking_course_id=bc88ac00-0c8c-4019-bacc-bf7bac0abbdf) | Open the link to access Node-RED online tool |
|  | Insert the following credentials:  user: lernfabrik  pw: L5nf1br|k  This tool establishes the communication to the factory |

# Exercise 2

a)

|  |  |
| --- | --- |
|  | Double Click |
|  | Click |
|  | 1. Click 2. Read |

b)

|  |  |
| --- | --- |
|  | 1. Right Tap on Consume MQTT 2. Tap View data provenance |
|  | 1. Click the info symbol of the message you are interested 2. Tap Content 3. Tap View |
|  | Complete MQTT-Message |

# Exercise 3

a)

|  |  |
| --- | --- |
|  | 1. Click new 2. Click terminal |
|  | Type into terminal   1. Go to directory 2. Execute order |
| A workpiece with color “BLUE” has been ordered.  Connected to broker via TCP.  Process was successful. | Answer of terminal |

b)

|  |  |
| --- | --- |
|  | Type |
| Current factory state: ORDERED | Response of terminal |

# Exercise 4

|  |  |
| --- | --- |
| Ein Bild, das Text, Screenshot, Schrift, Zahl enthält.  Automatisch generierte Beschreibung | 1. Open JupyterHub 2. Double click ki-campus folder |
| Ein Bild, das Text, Screenshot, Schrift, Reihe enthält.  Automatisch generierte Beschreibung | Double click modul\_4 folder |
| Ein Bild, das Text, Screenshot, Schrift enthält.  Automatisch generierte Beschreibung | Open notebook by double click |
| Ein Bild, das Text, Schrift, Zahl, Software enthält.  Automatisch generierte Beschreibung | Execute the notebook by clicking Restart & Run All |
| Ein Bild, das Reihe, Text, Handschrift, Diagramm enthält.  Automatisch generierte Beschreibung | Brightness in % is sinkings |
| Ein Bild, das Reihe, Diagramm, Handschrift, Text enthält.  Automatisch generierte Beschreibung | Brightness sensor value is increasing |
|  | Temperature in °C is increasing in the beginning, then falling and increasing rapidly and changing slightly in the end |
| Ein Bild, das Reihe, Diagramm enthält.  Automatisch generierte Beschreibung | Humidity is falling in the beginning, then rising and falling over the time |
|  | Air quality value is decreasing in the beginning, then rising softly towards an asymptote |

# Exercise 5

a)

|  |  |
| --- | --- |
| Open Node RED, sign in |  |
|  | Click on Flow order to reach the flow, that is used to control the factory |
|  |  |
|  | OPC UA Client node should show “value written” |

b)

|  |  |
| --- | --- |
| Trigger order like shown in a) |  |
|  | In the upper right corner, click on the bug to open the debug feed |
|  | Wait for confirmation that a order has been placed  Read the time the order has been placed: 5:18,36AM |
|  | Wait during messages that show “IN\_PROCESS” and “SHIPPED” |
|  | Read the time in the message showing “WAITING\_FOR\_ORDER”: 5:22,36AM |
| 5:22,36AM - 5:18,36AM = 4min | Calculate the duration |

c)

|  |  |
| --- | --- |
| -Trigger the same process like in b)  -Goal of this task is to understand the messages issued in the  debug window |  |
| Ein Bild, das Text, Screenshot, Schrift, Zahl enthält.  Automatisch generierte Beschreibung | Order triggered for red piece |
| Ein Bild, das Text, Schrift enthält.  Automatisch generierte Beschreibung | Confirmation that red piece is ordered |
|  | * This section shows the current stock * Every container has the following attributes: RFID, state if raw or already worked on and colour * Courser shows an empty space, the space is empty because of the placed order |
|  | * This section shows the states of each production step * The second column show the name of each station * The courser is pointing on the column indicating the state of each station   1: Ready  2: Currently working   * The last column is indicating the station where the workpiece is at |
| Ein Bild, das Text, Schrift, weiß, Algebra enthält.  Automatisch generierte Beschreibung | Indicates that production is finished |
|  | High rack storage has no empty slots anymore |

Ein Bild, das Text, Screenshot, Schrift, Farbigkeit enthält.

Automatisch generierte BeschreibungAbbreviation table for stations

# Exercise 7

|  |  |
| --- | --- |
|  | 1. Navigate to modul\_7 folder in jupyter 2. Open the marked notebook |
|  | Execute the notebook by clicking Restart & Run All |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 58ms/step  aktualisierte Datenreihe [0 1 0 1 0 0 1 0 1 0 1 0 1] ergibt den Zustand: Ruhend  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 58ms/step  Actualized series of data [0 1 0 1 0 0 1 0 1 0 1 0 1] results in state: Neutral | * Scroll down to the end of the script until the message on the left * It says that the factory is currently resting |
|  | Open a new terminal and navigate to cli-client folder |
| python3 lernfabrik.py -o BLUE | Insert the text on the left, this will trigger the order of a blue piece |
| Neue Message mit Topic: f/s/state/hbw  current threads = 9  1/1 [==============================] - 0s 56ms/step  aktualisierte Datenreihe [0 2 0 1 0 0 1 0 1 0 1 0 1] ergibt den Zustand: Ein-/Auslagerung  New Message with topic: f/s/state/hbw  current threads = 9  1/1 [==============================] - 0s 56ms/step  Actualized series of data [0 2 0 1 0 0 1 0 1 0 1 0 1] results in state: to (take out of) warehouse | * Go back to the notebook * Wait for new messages to show up * “Ein-/Auslagerung” means that the production process has begun as a workpieces is taken out of the warehouse |
| Comment: A series of messages will pop up, as a data query is send periodically. It is possible that single messages show a wrong state which can be ignored. | |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 72ms/step  aktualisierte Datenreihe [1 1 0 2 0 0 1 0 1 0 1 0 1] ergibt den Zustand: Transport  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 72ms/step  Actualized series of data [1 1 0 2 0 0 1 0 1 0 1 0 1] results in state: Transport | Next message will indicate that the gripper station is now running |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 76ms/step  aktualisierte Datenreihe [0 2 0 2 0 0 2 0 1 0 1 0 1] ergibt den Zustand: Bearbeitung  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 76ms/step  Actualized series of data [0 2 0 2 0 0 2 0 1 0 1 0 1] results in state: Workmanship | This message indicates that the workpiece is worked on |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 59ms/step  aktualisierte Datenreihe [0 1 0 1 0 0 1 1 2 0 1 0 1] ergibt den Zustand: Sortierung  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 59ms/step  Actualized series of data [0 1 0 1 0 0 1 1 2 0 1 0 1] results in state: Sorting | This message indicates that the colour sorting process is running |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 55ms/step  aktualisierte Datenreihe [0 1 1 2 3 0 1 0 1 0 1 0 1] ergibt den Zustand: TransportToDSO  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 55ms/step  Actualized series of data [0 1 1 2 3 0 1 0 1 0 1 0 1] results in state: TransportToDSO | This message indicates that the workpiece is transferred to the output station |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 67ms/step  aktualisierte Datenreihe [0 2 1 2 2 0 1 0 1 1 0 0 1] ergibt den Zustand: TransportToHBW  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 67ms/step  Actualized series of data [0 2 1 2 2 0 1 0 1 1 0 0 1] results in state: TransportToHBW | This message indicates that the workpiece is transported back to the warehouse |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 59ms/step  aktualisierte Datenreihe [1 2 0 2 0 0 1 0 1 0 1 0 1] ergibt den Zustand: Ein-/Auslagerung  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 59ms/step  Actualized series of data [1 2 0 2 0 0 1 0 1 0 1 0 1] results in state: to (take out of) warehouse | This message indicates that the piece is stored |
| Neue Message mit Topic: f/s/state/hbw  1/1 [==============================] - 0s 33ms/step  aktualisierte Datenreihe [0 1 0 1 0 0 1 0 1 0 1 0 1] ergibt den Zustand: Ruhend  New Message with topic: f/s/state/hbw  1/1 [==============================] - 0s 33ms/step  Actualized series of data [0 1 0 1 0 0 1 0 1 0 1 0 1] results in state: Neutral | After the process has finished, the neutral message is shown again |

REFERENCES

Itrich, A. & Klein, *M.. Lernfabrik 4.0 - Steuerung, Monitoring und NN-Modell (fischertechnik).* Albstadt-Sigmaringen. 2022