

1. The tasks described in this worksheet are part of the formative assessment. They serve the purpose to prepare you for the examination. We will discuss the solutions during the next **interactive session** after they are handed out – while they fit to the lecture of the week they are handed out, they might be discussed in two weeks time due to the bi-weekly exercise schedule.
2. Make sure to plan your time for the whole sheet carefully. The complete exercise should represent approximately three hours of independent study. The time limit indicates how much time you should spend on each task, and not how much time you may actually need; it is important that you engage with the material and not that you complete all tasks perfectly. Feel free to collaborate and team up.
3. The exercises are designed to challenge you and train you further as guided self-study. The time limit might be too ambitious for you; you may team up with colleagues. It is not an issue as long as you manage to at least partially resolve each task within the time budget. If you (and team) are struggling, reach out for help in Teams! You may also share your thoughts on the channel.
4. We recommend that you create a (private) GIT repository where you store your findings and outcomes while processing the exercises. This portfolio of work could be useful in the future.

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Task 1: Introduction: Understanding HPDA Use Cases (60 min)

Being able to describe typical HPDA use cases is important. In this task, you will research two different use cases.

Tasks

1. Research one recent HPDA use case from industry in the literature, e.g., using Google or Google Scholar. Describe the use case briefly, put an emphasis on performance relevant characteristics, e.g., how much data do they process, how long does the workflow run? Address how the Big Data Challenges (5V) apply. Make sure you cite the used literature properly! Your notes should cover about 1/4-page.
2. Research a scientific HPDA use case following the same instructions as above.

Portfolio (directory: 1/performance)

1/performance/hdpa-use-case-industry.txt The use case from industry.
1/performance/hdpa-use-case-science.txt The use case description from science.

Task 2: Bash Exercises (60 min)

Supercomputers and distributed computers often use Linux to interact with them. This exercise aids to provide an introduction to bash programming to improve your current knowledge. If you are already proficient, please do the (harder) follow up task instead.

We don't expect for you to be writing long and complex bash scripts straight away. We also appreciate that moving to a CLI (Command Line Interface), while powerful, can be challenging especially when you are accustomed to interacting with primarily graphical interfaces on Operating Systems like Windows.

Below we have included several Bash commands of varying complexity that also cover more advanced concepts of the Bash. We want you to experiment with them, try running them and observe the result! Think about what you expect their output to be before you run them. Perhaps make your own changes to the commands. Use this as an opportunity to learn about the shell and increase your comfort in writing your own scripts.

We would like you to produce a text file providing a short descriptions of your findings, i.e. all you need to provide is a brief description of what the command does (if possible write what you expected) and a short explanation of how it works where appropriate.

Run the following command **BEFORE** beginning the exercise, this command will create a directory and change your current directory to it:

```
$ mkdir -p $HOME/exercise1 && cd $HOME/exercise1
```

You should complete the steps below in this directory.

1. `$ echo "Hello World"`
2. `$ echo Hello, World`
3. `$ echo Hello, world; Foo bar`
4. `$ echo Hello, world!`
5. `$ echo "line one";echo "line two"`
6. `$ echo "Hello, world > readme"`
7. `$ echo "Hello, world" > readme`
8. `$ cat readme`
9. `$ example="Hello, World"`
10. `$ echo $example`
11. `$ echo '$example'`
12. `$ echo "$example"`
13. `$ echo "Please enter your name."; read example`
14. `$ echo "Hello $example"`
15. `$ three=1+1+1;echo $three`
16. `$ bc`

```
17. $ echo 1+1+1 | bc
18. $ let three=1+1+1;echo $three
19. $ echo date
20. $ cal
21. $ which cal
22. $ /bin/cal
23. $ $(which cal)
24. $ `which cal`
25. $ echo "The date is $(date)"
26. $ seq 0 9
27. $ seq 0 9 | wc -l
28. $ seq 0 9 > sequence
29. $ wc -l < sequence
30. $ for I in $(seq 1 9) ; do echo $I ; done
31. $ (echo -n 0 ; for I in $(seq 1 9) ; do echo -n +$I ; done ; echo) | bc
```

Hints

- Use the up/down arrows to browse the history of the shell to find recently used commands
- Use the left/right arrows (Pos1/End keys) to change the position of the text cursor
- Use the tab key to autocomplete commands when you're halfway through typing them - it saves time!
- The middle mouse key copies previously marked text into the shell
- Bash has certain special characters such as ;!<> that can cause unexpected behaviour when included outside of quotes in a command.
- Use the command `$ help` and `$ man` to find out what a specific command does.

Portfolio (directory: 1/bash)

1/bash/findings.txt An enumerated list that provides for each command a prose sentence what the commands did. Where your expectation differs from observed behavior, include a sentence describing what surprised you. (at least 200 words).

Further Reading

- Shell scripting (also available as PDF) <https://www.shellscript.sh/>
- Shebang Wikipedia: [https://en.wikipedia.org/wiki/Shebang_\(Unix\)](https://en.wikipedia.org/wiki/Shebang_(Unix))
- Commands: <https://maker.pro/linux/tutorial/basic-linux-commands-for-beginners>
- Command line structure: https://www2.cs.duke.edu/csl/docs/unix_course/intro-14.html

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- https://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard

Task 2: Bash Research (60 min)

This is a more difficult **optional** task which can be done instead of Task 2

We would like for you to produce a short (about 1 page, at least 300 words) report on the core concepts behind bash and shown them in practice. Your report should give brief explanations and examples of the following concepts:

- Special characters and escaping
- Redirection
- Piping
- Variables
- Arithmetic
- Common Commands that you find useful beyond our examples (`ls`, `cd`, `mkdir`, ...)

You should include examples from the alternative (easy) task.

In your report you should consider circumstances in which easily avoidable errors could be encountered and subsequently avoided in your commands (for example, unescaped special characters such as `;!#&`)

Portfolio (directory: 1/bash)

1/bash/report.txt The 300 words report describing the concepts relevant to Task 1.

Further Reading

- <https://learnxinyminutes.com/docs/bash/> - Usage examples of many common bash commands.
- https://www.gnu.org/software/bash/manual/html_node/Quoting.html - Nice guide to how quotes work in Bash
- <https://jvns.ca/blog/2017/03/26/bash-quirks/> - Article going over basics and some common quirks in the language which can trip up beginners.
- <https://www.geeksforgeeks.org/piping-in-unix-or-linux/> - Covers piping and its application.
- Advanced Bash-Scripting Guide: I/O Redirection: <https://www.tldp.org/LDP/abs/html/io-redirection.html>

Task 3: Setup of the software environment in a Virtual Machine (60 min)

To get started with a development environment and conduct all (formative) exercises, we suggest to install a VirtualMachine with Ubuntu 20.04 using VirtualBox¹ – if you have VMWare, it works fine too. We could also provide an image, however, it is a good learning experience to set it up by yourself. Details about the usage of a VM are noted in the Google Doc here; several introductory videos are provided. Also, familiarize with the typical remote connection using SSH [2].

¹<https://www.virtualbox.org/>

VirtualBox is a free virtualization environment allowing you to run virtual machines on your system (the host system).

Tasks

1. Familiarize with SSH [2]. Create a private/public key. (look for, e.g., PUTTY [3] in Windows)
2. Download the Ubuntu minimal ISO.
3. Install Ubuntu via VirtualBox. You may have to adjust the network settings (see [4.]).
4. Install Git and openssh-server via: `$ apt install git openssh-server openjdk-11-jdk`
5. We allow SSH to connect from the virtual machine to itself: `$ ssh-keygen`
Confirm the key creation, pressing enter. Do not enter any keyphrase here. Now, we install this new key:
`$ cat ~/.ssh/id_rsa.pub > ~/.ssh/authorized_keys`
Test the setup by running: `$ ssh localhost`
Confirm the SSH Fingerprint with yes. Now you can logout again using CTRL-D or exit.
6. Connect via SSH from your Hostsystem to the virtual machine. Import the SSH public key in Linux to your `~/.ssh/authorized_keys` file.
7. Clone the repository for the course: `$ git clone https://github.com/JulianKunkel/hpda-samples.git`
8. Attempt to install Spark via: `$ cd hpda-samples/install; sudo ./spark.sh`
9. Test that Hadoop works in standalone mode:
`$ source ./test/hadoop.sh ; hadoop fs -ls`
This should show the files in the home directory. With source, we load the required environment variables.
10. Test that Spark runs: `$ pyspark`. Then insert the following program:

```
1 rdd = sc.parallelize(["b", "a"])
2 sorted(rdd.map(lambda x: (x, 1)).collect())
```

This should output: `[('a', 1), ('b', 1)]`

11. Test that MongoDB [6] works:

```
1 sudo /etc/init.d/mongodb start
2 cd ./test/
3 ./mongo.py
```

Congratulations, it appears that the software is generally working for you!

Portfolio (directory: 1/vm)

`1/vm/software.txt` Short comments regarding your steps and issues that arose.

Hints

- You can become root (the superuser) using the command `$ sudo` in the shell.
- The IP Address is shown with the command `$ ip addr show`.
- By default, the SSH port has been forwarded to the VirtualMachine, i.e., you have to use `$ ssh -p 2222 USERNAME@localhost`
Where the username corresponds to the one you used in Ubuntu.

Further Reading

1. Installation for Hadoop in standalone mode <https://www.digitalocean.com/community/tutorials/how-to-install-hadoop-in-stand-alone-mode-on-ubuntu-18-04>
2. SSH Keygen <https://www.ssh.com/ssh/keygen/>
3. PuttyGen <https://www.ssh.com/ssh/putty/windows/puttygen>
4. VirtualBox Network <https://www.virtualbox.org/manual/ch06.html>
5. PySpark <https://spark.apache.org/docs/latest/api/python/index.html>
6. PyMongo <https://api.mongodb.com/python/current/>

Task 4: Reading CSV Data (Python) (60 min)

A popular, portable, file format for structured data is CSV. In this task, you will read a CSV file and print the mean of one of its columns. Your program should potentially work with any CSV file (conforming to certain standards). The user should be able to specify which column's mean is printed from the command line. Your program in Python should be run like this:

```
python csv.py [FILE] [COLUMN_NUMBER]
```

Create a sample CSV file using Libreoffice (or MS Excel).

Complete the following tasks:

- Compute and print the mean of the `deltatime` column using your program.
- Use the Unix-tool `time` to evaluate the performance of both your programs. Which one does perform better?

4.1 Hints and Code-Skeleton

You *may* use the following structure and function (feel free to use any other function from the standard libraries if they help you, but don't use functions that parse the CSV for you).

4.1.1 Python

```
1 import sys
2
3 # Commandline arguments are available in the sys.argv list
4 print(sys.argv)
5
6 # Implement this function, do not use a function to completely parse the CSV file!
7 def computeMeanCSV(filename, column_number):
8     ...
9     return mean
```

Portfolio (directory: 1/csv)

- | | |
|---------------------|----------------------------------------------------|
| 1/csv/csv.py | Your source code |
| 1/csv/csv-speed.txt | Your runtime measurements with a short evaluation. |