Open in Colab

BPL_TEST2_Perfusion script with PyFMI ver 2.9.8

The key library PyFMI v2.9.8 is installed.

After the installation a small application BPL_TEST2_Perfusion is loaded and run. You can continue with this example if you like.

In [ ]:
```
!lsb_release -a # Actual VM Ubuntu version used by Google
```

```
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 20.04.5 LTS
Release:        20.04
Codename:       focal
```

In [ ]:
```
%env PYTHONPATH=
```

```
env: PYTHONPATH=
```

In [ ]:
```
!wget https://repo.anaconda.com/miniconda/Miniconda3-py38_22.11.1-1-Linux
!chmod +x Miniconda3-py38_22.11.1-1-Linux-x86_64.sh
!bash ./Miniconda3-py38_22.11.1-1-Linux-x86_64.sh -b -f -p /usr/local
import sys
sys.path.append('/usr/local/lib/python3.8/site-packages/')
```

```
--2023-01-25 10:17:20--  https://repo.anaconda.com/miniconda/Miniconda3-
py38_22.11.1-1-Linux-x86_64.sh
Resolving repo.anaconda.com (repo.anaconda.com)... 104.16.131.3, 104.16.
130.3, 2606:4700::6810:8203, ...
Connecting to repo.anaconda.com (repo.anaconda.com)|104.16.131.3|:443...
connected.
HTTP request sent, awaiting response... 200 OK
Length: 64630241 (62M) [application/x-sh]
Saving to: ‘Miniconda3-py38_22.11.1-1-Linux-x86_64.sh’

Miniconda3-py38_22. 100%[===================>]  61.64M   124MB/s    in
0.5s

2023-01-25 10:17:21 (124 MB/s) - ‘Miniconda3-py38_22.11.1-1-Linux-x86_6
4.sh’ saved [64630241/64630241]

PREFIX=/usr/local
Unpacking payload ...

Installing base environment...


Downloading and Extracting Packages


Downloading and Extracting Packages

Preparing transaction: -   \   |   /   -   \   done
Executing transaction: /   -   \   |   /   -   \   |   /   -   \   |   /
  -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \
  |   /   -   \   |   /   -   \   |   /   -   done
installation finished.
```

In [ ]:
```
!conda update -n base -c defaults conda --yes
```

```
Collecting package metadata (current_repodata.json): -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   done
Solving environment: |   /   -   \   |   /   -   \   |   /   -   \   |
  done

## Package Plan ##

  environment location: /usr/local

  added / updated specs:
    - conda


The following packages will be downloaded:

    package                    |            build
    ---------------------------|-----------------
    ca-certificates-2023.01.10 |       h06a4308_0         120 KB
    conda-23.1.0               |   py38h06a4308_0         942 KB
    conda-package-handling-2.0.2|   py38h06a4308_0         267 KB
    conda-package-streaming-0.7.0|   py38h06a4308_0          26 KB
    cryptography-38.0.4        |   py38h9ce1e76_0         1.4 MB
    sqlite-3.40.1              |       h5082296_0         1.2 MB
    urllib3-1.26.14            |   py38h06a4308_0         196 KB
    xz-5.2.10                  |       h5eee18b_1         429 KB
    zstandard-0.18.0           |   py38h5eee18b_0         434 KB
    ------------------------------------------------------------
                                           Total:         4.9 MB

The following NEW packages will be INSTALLED:

  conda-package-str~ pkgs/main/linux-64::conda-package-streaming-0.7.0-p
y38h06a4308_0
  zstandard          pkgs/main/linux-64::zstandard-0.18.0-py38h5eee18b_0

The following packages will be UPDATED:

  ca-certificates                     2022.10.11-h06a4308_0 --> 2023.01.
10-h06a4308_0
  conda                              22.11.1-py38h06a4308_4 --> 23.1.0-p
y38h06a4308_0
  conda-package-han~                   1.9.0-py38h5eee18b_1 --> 2.0.2-py
38h06a4308_0
  cryptography                        38.0.1-py38h9ce1e76_0 --> 38.0.4-p
y38h9ce1e76_0
  sqlite                                 3.40.0-h5082296_0 --> 3.40.1-h
5082296_0
  urllib3                            1.26.13-py38h06a4308_0 --> 1.26.14-
py38h06a4308_0
  xz                                      5.2.8-h5eee18b_0 --> 5.2.10-h
5eee18b_1



Downloading and Extracting Packages
ca-certificates-2023 | 120 KB    | :   0% 0/1 [00:00<?, ?it/s]
sqlite-3.40.1        | 1.2 MB    | :   0% 0/1 [00:00<?, ?it/s]

urllib3-1.26.14      | 196 KB    | :   0% 0/1 [00:00<?, ?it/s]
```

```
conda-package-handli | 267 KB    | :   0% 0/1 [00:00<?, ?it/s]

zstandard-0.18.0     | 434 KB    | :   0% 0/1 [00:00<?, ?it/s]

conda-package-stream | 26 KB     | :   0% 0/1 [00:00<?, ?it/s]

conda-23.1.0         | 942 KB    | :   0% 0/1 [00:00<?, ?it/s]

xz-5.2.10            | 429 KB    | :   0% 0/1 [00:00<?, ?it/s]

cryptography-38.0.4  | 1.4 MB    | :   0% 0/1 [00:00<?, ?it/s]
sqlite-3.40.1        | 1.2 MB    | :  17% 0.1743092837501637/1 [00:00<0
0:00,  1.72it/s]

urllib3-1.26.14      | 196 KB    | :  57% 0.5716592813386302/1 [00:00<0
0:00,  5.53it/s]

zstandard-0.18.0     | 434 KB    | :  15% 0.1476335293190061/1 [00:00<0
0:00,  1.41it/s]

conda-23.1.0         | 942 KB    | :   2% 0.016977341093890375/1 [00:00<
00:07,  7.42s/it]

xz-5.2.10            | 429 KB    | :   4% 0.037267448076008854/1 [00:00<
00:03,  3.58s/it]
```

```
conda-package-stream | 26 KB     | :  61% 0.6093197961991893/1 [00:00<0
0:00,  4.42it/s]
```

```
ca-certificates-2023 | 120 KB    | : 100% 1.0/1 [00:00<00:00,  4.95it/s]
```

```
conda-package-handli | 267 KB    | : 100% 1.0/1 [00:00<00:00,  4.12it/s]
```

```
conda-package-handli | 267 KB    | : 100% 1.0/1 [00:00<00:00,  4.12it/s]
```

```
urllib3-1.26.14      | 196 KB    | : 100% 1.0/1 [00:00<00:00,  5.53it/s]
```

```
zstandard-0.18.0     | 434 KB    | : 100% 1.0/1 [00:00<00:00,  3.05it/s]
```

```
zstandard-0.18.0     | 434 KB    | : 100% 1.0/1 [00:00<00:00,  3.05it/s]
```

```
conda-package-stream | 26 KB     | : 100% 1.0/1 [00:00<00:00,  4.42it/s]
sqlite-3.40.1        | 1.2 MB    | : 100% 1.0/1 [00:00<00:00,  2.23it/s]
sqlite-3.40.1        | 1.2 MB    | : 100% 1.0/1 [00:00<00:00,  2.23it/s]
```

```
xz-5.2.10            | 429 KB    | : 100% 1.0/1 [00:00<00:00,  2.04it/s]
```

```
xz-5.2.10            | 429 KB    | : 100% 1.0/1 [00:00<00:00,  2.04it/s]
```

```
conda-23.1.0         | 942 KB    | : 100% 1.0/1 [00:00<00:00,  1.70it/s]
```

```
conda-23.1.0         | 942 KB    | : 100% 1.0/1 [00:00<00:00,  1.70it/s]
```

```
cryptography-38.0.4  | 1.4 MB    | : 100% 1.0/1 [00:00<00:00,  1.47it/s]
```

```
Preparing transaction: -   done
Verifying transaction: |   /   done
Executing transaction: \   |   done
```

In [ ]:
```
!conda --version
!python --version
```

```
conda 23.1.0
Python 3.8.15
```

In [ ]:
```
!conda install -c conda-forge pyfmi --yes # Install the key package
```

```
Collecting package metadata (current_repodata.json): -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   done
Solving environment: |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |
  /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -
  \   |   /   -   \   |   /   -   \   |   /   done

## Package Plan ##

  environment location: /usr/local

  added / updated specs:
    - pyfmi


The following packages will be downloaded:

    package                    |            build
    ---------------------------|-----------------
    _libgcc_mutex-0.1          |      conda_forge           3 KB  conda-
forge
    _openmp_mutex-4.5          |       2_kmp_llvm           6 KB  conda-
forge
    appdirs-1.4.4              |     pyh9f0ad1d_0          13 KB  conda-
forge
    assimulo-3.3               |   py38h71f17ff_1         2.4 MB  conda-
forge
    ca-certificates-2022.12.7  |       ha878542_0         143 KB  conda-
forge
    certifi-2022.12.7          |     pyhd8ed1ab_0         147 KB  conda-
forge
    fmilib-2.4.1               |       h27087fc_0         545 KB  conda-
forge
    gmp-6.2.1                  |       h58526e2_0         806 KB  conda-
forge
    icu-58.2                   |    hf484d3e_1000        22.6 MB  conda-
forge
    libblas-3.9.0              |16_linux64_openblas          13 KB  cond
a-forge
    libcblas-3.9.0             |16_linux64_openblas          13 KB  cond
a-forge
    libgcc-ng-12.2.0           |      h65d4601_19         931 KB  conda-
forge
    libgfortran-ng-12.2.0      |      h69a702a_19          22 KB  conda-
forge
    libgfortran5-12.2.0        |      h337968e_19         1.8 MB  conda-
forge
    libhwloc-2.8.0             |       h32351e8_1         3.0 MB  conda-
forge
    liblapack-3.9.0            |16_linux64_openblas          13 KB  cond
```

```
a-forge
    libopenblas-0.3.21         |pthreads_h78a6416_3        10.1 MB  cond
a-forge
    libstdcxx-ng-12.2.0        |      h46fd767_19         4.3 MB  conda-
forge
    libxml2-2.9.14             |       h74e7548_0         718 KB
    libxslt-1.1.35             |       h4e12654_0         453 KB
    llvm-openmp-14.0.6         |       h9e868ea_0         4.4 MB
    lxml-4.9.1                 |   py38h1edc446_0         1.3 MB
    metis-5.1.0                |    h58526e2_1006         4.1 MB  conda-
forge
    mpfr-4.1.0                 |       h9202a9a_1         2.6 MB  conda-
forge
    numpy-1.24.1               |   py38hab0fcb9_0         6.3 MB  conda-
forge
    openssl-1.1.1s             |       h0b41bf4_1         1.9 MB  conda-
forge
    packaging-23.0             |     pyhd8ed1ab_0          40 KB  conda-
forge
    pooch-1.6.0                |     pyhd8ed1ab_0          44 KB  conda-
forge
    pyfmi-2.9.8                |   py38h26c90d9_1        12.7 MB  conda-
forge
    python_abi-3.8             |           2_cp38           4 KB  conda-
forge
    scipy-1.10.0               |   py38h10c12cc_0        23.5 MB  conda-
forge
    suitesparse-5.10.1         |       h9e50725_1         2.4 MB  conda-
forge
    sundials-6.4.1             |       h89a52a3_0         1.2 MB  conda-
forge
    tbb-2021.7.0               |       h924138e_1         1.5 MB  conda-
forge
    ------------------------------------------------------------
                                           Total:       109.6 MB

The following NEW packages will be INSTALLED:

  appdirs            conda-forge/noarch::appdirs-1.4.4-pyh9f0ad1d_0
  assimulo           conda-forge/linux-64::assimulo-3.3-py38h71f17ff_1
  fmilib             conda-forge/linux-64::fmilib-2.4.1-h27087fc_0
  gmp                conda-forge/linux-64::gmp-6.2.1-h58526e2_0
  icu                conda-forge/linux-64::icu-58.2-hf484d3e_1000
  libblas            conda-forge/linux-64::libblas-3.9.0-16_linux64_open
blas
  libcblas           conda-forge/linux-64::libcblas-3.9.0-16_linux64_ope
nblas
  libgfortran-ng     conda-forge/linux-64::libgfortran-ng-12.2.0-h69a702
a_19
  libgfortran5       conda-forge/linux-64::libgfortran5-12.2.0-h337968e_
19
  libhwloc           conda-forge/linux-64::libhwloc-2.8.0-h32351e8_1
  liblapack          conda-forge/linux-64::liblapack-3.9.0-16_linux64_op
enblas
  libopenblas        conda-forge/linux-64::libopenblas-0.3.21-pthreads_h
78a6416_3
  libxml2            pkgs/main/linux-64::libxml2-2.9.14-h74e7548_0
  libxslt            pkgs/main/linux-64::libxslt-1.1.35-h4e12654_0
  llvm-openmp        pkgs/main/linux-64::llvm-openmp-14.0.6-h9e868ea_0
  lxml               pkgs/main/linux-64::lxml-4.9.1-py38h1edc446_0
```

```
  metis              conda-forge/linux-64::metis-5.1.0-h58526e2_1006
  mpfr               conda-forge/linux-64::mpfr-4.1.0-h9202a9a_1
  numpy              conda-forge/linux-64::numpy-1.24.1-py38hab0fcb9_0
  packaging          conda-forge/noarch::packaging-23.0-pyhd8ed1ab_0
  pooch              conda-forge/noarch::pooch-1.6.0-pyhd8ed1ab_0
  pyfmi              conda-forge/linux-64::pyfmi-2.9.8-py38h26c90d9_1
  python_abi         conda-forge/linux-64::python_abi-3.8-2_cp38
  scipy              conda-forge/linux-64::scipy-1.10.0-py38h10c12cc_0
  suitesparse        conda-forge/linux-64::suitesparse-5.10.1-h9e50725_1
  sundials           conda-forge/linux-64::sundials-6.4.1-h89a52a3_0
  tbb                conda-forge/linux-64::tbb-2021.7.0-h924138e_1

The following packages will be REMOVED:

  libgomp-11.2.0-h1234567_1

The following packages will be UPDATED:

  libgcc-ng          pkgs/main::libgcc-ng-11.2.0-h1234567_1 --> conda-fo
rge::libgcc-ng-12.2.0-h65d4601_19
  libstdcxx-ng       pkgs/main::libstdcxx-ng-11.2.0-h12345~ --> conda-fo
rge::libstdcxx-ng-12.2.0-h46fd767_19
  openssl              pkgs/main::openssl-1.1.1s-h7f8727e_0 --> conda-fo
rge::openssl-1.1.1s-h0b41bf4_1

The following packages will be SUPERSEDED by a higher-priority channel:

  _libgcc_mutex           pkgs/main::_libgcc_mutex-0.1-main --> conda-fo
rge::_libgcc_mutex-0.1-conda_forge
  _openmp_mutex          pkgs/main::_openmp_mutex-5.1-1_gnu --> conda-fo
rge::_openmp_mutex-4.5-2_kmp_llvm
  ca-certificates    pkgs/main::ca-certificates-2023.01.10~ --> conda-fo
rge::ca-certificates-2022.12.7-ha878542_0
  certifi            pkgs/main/linux-64::certifi-2022.12.7~ --> conda-fo
rge/noarch::certifi-2022.12.7-pyhd8ed1ab_0



Downloading and Extracting Packages
libxml2-2.9.14       | 718 KB    | :   0% 0/1 [00:00<?, ?it/s]
packaging-23.0       | 40 KB     | :   0% 0/1 [00:00<?, ?it/s]

pooch-1.6.0          | 44 KB     | :   0% 0/1 [00:00<?, ?it/s]


mpfr-4.1.0           | 2.6 MB    | :   0% 0/1 [00:00<?, ?it/s]



pyfmi-2.9.8          | 12.7 MB   | :   0% 0/1 [00:00<?, ?it/s]




libcblas-3.9.0       | 13 KB     | :   0% 0/1 [00:00<?, ?it/s]
```

```
lxml-4.9.1           | 1.3 MB    | :   0% 0/1 [00:00<?, ?it/s]

icu-58.2             | 22.6 MB   | :   0% 0/1 [00:00<?, ?it/s]

gmp-6.2.1            | 806 KB    | :   0% 0/1 [00:00<?, ?it/s]

tbb-2021.7.0         | 1.5 MB    | :   0% 0/1 [00:00<?, ?it/s]

_openmp_mutex-4.5    | 6 KB      | :   0% 0/1 [00:00<?, ?it/s]

scipy-1.10.0         | 23.5 MB   | :   0% 0/1 [00:00<?, ?it/s]

certifi-2022.12.7    | 147 KB    | :   0% 0/1 [00:00<?, ?it/s]
```

```
liblapack-3.9.0      | 13 KB     | :   0% 0/1 [00:00<?, ?it/s]
```

```
libgfortran-ng-12.2. | 22 KB     | :   0% 0/1 [00:00<?, ?it/s]
```

```
python_abi-3.8       | 4 KB      | :   0% 0/1 [00:00<?, ?it/s]
```

```
libxslt-1.1.35       | 453 KB    | :   0% 0/1 [00:00<?, ?it/s]
```

```
llvm-openmp-14.0.6   | 4.4 MB    | :   0% 0/1 [00:00<?, ?it/s]

libhwloc-2.8.0       | 3.0 MB    | :   0% 0/1 [00:00<?, ?it/s]

libxml2-2.9.14       | 718 KB    | :  13% 0.1336825528928924/1 [00:00<0
0:00,  1.33it/s]
pooch-1.6.0          | 44 KB     | :  37% 0.36539619527643347/1 [00:00<0
0:00,  3.62it/s]

mpfr-4.1.0           | 2.6 MB    | :   1% 0.0060485553093571716/1 [00:00
<00:16, 17.03s/it]
packaging-23.0       | 40 KB     | :  40% 0.4028918506860768/1 [00:00<0
0:00,  3.66it/s]
```

```
libcblas-3.9.0       | 13 KB     | : 100% 1.0/1 [00:00<00:00,  7.13it/s]



lxml-4.9.1           | 1.3 MB    | :   1% 0.012074003382548555/1 [00:00<
00:13, 13.68s/it]



pyfmi-2.9.8          | 12.7 MB   | :   0% 0.0012299889380572495/1 [00:00
<02:18, 138.84s/it]



gmp-6.2.1            | 806 KB    | :   2% 0.019840539414665338/1 [00:00<
00:08,  8.71s/it]

mpfr-4.1.0           | 2.6 MB    | :  79% 0.7863121902164323/1 [00:00<0
0:00,  4.52it/s]



icu-58.2             | 22.6 MB   | :   0% 0.0006924013097812081/1 [00:00
<05:06, 306.75s/it]
packaging-23.0       | 40 KB     | : 100% 1.0/1 [00:00<00:00,  3.94it/s]
packaging-23.0       | 40 KB     | : 100% 1.0/1 [00:00<00:00,  3.94it/s]



pyfmi-2.9.8          | 12.7 MB   | :   7% 0.07379933628343498/1 [00:00<0
0:02,  3.04s/it]



tbb-2021.7.0         | 1.5 MB    | :   1% 0.010517220793593123/1 [00:00<
00:25, 25.61s/it]
```

```
_openmp_mutex-4.5    | 6 KB      | : 100% 1.0/1 [00:00<00:00,  3.39it/s]


icu-58.2             | 22.6 MB   | :   7% 0.06993253228790201/1 [00:00<0
0:03,  3.60s/it]


scipy-1.10.0         | 23.5 MB   | :   0% 0.0006660983852196085/1 [00:00
<07:57, 477.46s/it]


certifi-2022.12.7    | 147 KB    | :  11% 0.10862920603348251/1 [00:00<0
0:02,  3.05s/it]

pooch-1.6.0          | 44 KB     | : 100% 1.0/1 [00:00<00:00,  2.55it/s]


pyfmi-2.9.8          | 12.7 MB   | :  19% 0.19187827433693094/1 [00:00<0
0:01,  1.51s/it]

pooch-1.6.0          | 44 KB     | : 100% 1.0/1 [00:00<00:00,  2.55it/s]


liblapack-3.9.0      | 13 KB     | : 100% 1.0/1 [00:00<00:00,  2.65it/s]
```

```
libgfortran-ng-12.2. | 22 KB     | :  72% 0.7159587484705471/1 [00:00<0
0:00,  1.79it/s]
```

```
python_abi-3.8       | 4 KB      | : 100% 1.0/1 [00:00<00:00,  2.43it/s]
```

```
scipy-1.10.0         | 23.5 MB   | :   5% 0.049291280506251034/1 [00:00<
00:06,  6.66s/it]
```

```
icu-58.2             | 22.6 MB   | :  14% 0.1357106567171168/1 [00:00<0
0:02,  2.55s/it]
```

```
pyfmi-2.9.8          | 12.7 MB   | :  31% 0.3062672455762551/1 [00:00<0
0:00,  1.23s/it]
```

```
llvm-openmp-14.0.6   | 4.4 MB    | :   0% 0.0035718910660429226/1 [00:00
<02:23, 143.88s/it]

scipy-1.10.0         | 23.5 MB   | :  11% 0.1085740367907962/1 [00:00<0
0:03,  3.51s/it]

icu-58.2             | 22.6 MB   | :  19% 0.18556355102136377/1 [00:00<0
0:01,  2.35s/it]

libxslt-1.1.35       | 453 KB    | :   4% 0.03535018997706466/1 [00:00<0
0:14, 14.98s/it]

libxml2-2.9.14       | 718 KB    | : 100% 1.0/1 [00:00<00:00,  1.70it/s]

pyfmi-2.9.8          | 12.7 MB   | :  47% 0.47354574115204107/1 [00:00<0
0:00,  1.07it/s]
```

```
libhwloc-2.8.0       | 3.0 MB    | :   1% 0.005266267282350226/1 [00:00<
01:53, 113.76s/it]
```

```
llvm-openmp-14.0.6   | 4.4 MB    | :  27% 0.27146372101926214/1 [00:00<0
0:01,  1.70s/it]
```

```
icu-58.2             | 22.6 MB   | :  25% 0.24857207021145372/1 [00:00<0
0:01,  2.04s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  15% 0.15120433344485115/1 [00:00<0
0:02,  3.19s/it]
```

```
pyfmi-2.9.8           | 12.7 MB   | :  64% 0.6371342699136553/1 [00:00<0
0:00,  1.23it/s]
```

```
libhwloc-2.8.0        | 3.0 MB    | :  50% 0.49502912454092124/1 [00:00<0
0:00,  1.05s/it]
```

```
llvm-openmp-14.0.6    | 4.4 MB    | :  65% 0.6536560650858548/1 [00:00<0
0:00,  1.35it/s]
```

```
icu-58.2              | 22.6 MB   | :  33% 0.3254286155971678/1 [00:00<0
0:01,  1.74s/it]
```

```
scipy-1.10.0          | 23.5 MB   | :  22% 0.217814171966812/1 [00:00<00:
01,  2.44s/it]
```

```
 ... (more hidden) ...
```

```
pyfmi-2.9.8          | 12.7 MB   | :  77% 0.7650531194716093/1 [00:00<0
0:00,  1.14it/s]
```

```
icu-58.2             | 22.6 MB   | :  40% 0.40436236491222555/1 [00:00<0
0:00,  1.57s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  29% 0.2850901088739925/1 [00:00<0
0:01,  2.07s/it]
```

```
 ... (more hidden) ...
```

```
pyfmi-2.9.8          | 12.7 MB   | :  94% 0.9397115486757387/1 [00:00<0
0:00,  1.27it/s]
```

```
icu-58.2             | 22.6 MB   | :  49% 0.4929897325642202/1 [00:00<0
0:00,  1.43s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  36% 0.3623575215594670 4/1 [00:00<0
0:01,  1.76s/it]
```

```
 ... (more hidden) ...
```

```
icu-58.2             | 22.6 MB   | :  56% 0.5649994687814658/1 [00:01<0
0:00,  1.44s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  44% 0.4369605407040632/1 [00:01<0
0:00,  1.61s/it]
```

```
icu-58.2             | 22.6 MB   | :  64% 0.6363168036889303/1 [00:01<0
0:00,  1.51s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  50% 0.5029042808408045/1 [00:01<0
0:00,  1.70s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  56% 0.5648514306662281/1 [00:01<0
0:00,  1.74s/it]
```

```
icu-58.2             | 22.6 MB   | :  70% 0.7041721320474886/1 [00:01<0
0:00,  1.82s/it]
```

```
scipy-1.10.0         | 23.5 MB   | :  64% 0.6367900562699458/1 [00:01<0
0:00,  1.63s/it]
```

```
icu-58.2            | 22.6 MB   | :  78% 0.7824134800527651/1 [00:01<0
0:00,  1.68s/it]
```

```
scipy-1.10.0        | 23.5 MB   | :  70% 0.7000694028658087/1 [00:01<0
0:00,  1.62s/it]
```

```
icu-58.2            | 22.6 MB   | :  86% 0.864809235916729/1 [00:01<00:
00,  1.54s/it]
```

```
scipy-1.10.0        | 23.5 MB   | :  78% 0.7800012090921616/1 [00:01<0
0:00,  1.50s/it]
```

```
icu-58.2            | 22.6 MB   | :  94% 0.9368189721339746/1 [00:01<0
0:00,  1.50s/it]
```

```
scipy-1.10.0        | 23.5 MB   | :  87% 0.8652618024002715/1 [00:01<0
0:00,  1.39s/it]
```

```
scipy-1.10.0          | 23.5 MB   | :  96% 0.9611799698718951/1 [00:01<0
0:00,  1.27s/it]
```

```
gmp-6.2.1             | 806 KB    | : 100% 1.0/1 [00:01<00:00,  1.83s/it]
```


```
gmp-6.2.1             | 806 KB    | : 100% 1.0/1 [00:01<00:00,  1.83s/it]
```


```
lxml-4.9.1            | 1.3 MB    | : 100% 1.0/1 [00:01<00:00,  1.92s/it]
```


```
lxml-4.9.1            | 1.3 MB    | : 100% 1.0/1 [00:01<00:00,  1.92s/it]
```


```
_openmp_mutex-4.5     | 6 KB      | : 100% 1.0/1 [00:01<00:00,  3.39it/s]
```

```
certifi-2022.12.7     | 147 KB    | : 100% 1.0/1 [00:01<00:00,  1.95s/it]
```

```
certifi-2022.12.7    | 147 KB    | : 100% 1.0/1 [00:01<00:00,  1.95s/it]

tbb-2021.7.0         | 1.5 MB    | : 100% 1.0/1 [00:02<00:00,  1.98s/it]

tbb-2021.7.0         | 1.5 MB    | : 100% 1.0/1 [00:02<00:00,  1.98s/it]

liblapack-3.9.0      | 13 KB     | : 100% 1.0/1 [00:02<00:00,  2.65it/s]

libgfortran-ng-12.2. | 22 KB     | : 100% 1.0/1 [00:02<00:00,  2.52s/it]
```

```
libgfortran-ng-12.2. | 22 KB     | : 100% 1.0/1 [00:02<00:00,  2.52s/it]
```

```
python_abi-3.8       | 4 KB      | : 100% 1.0/1 [00:02<00:00,  2.43it/s]
```

```
libxslt-1.1.35       | 453 KB    | : 100% 1.0/1 [00:02<00:00,  2.08s/it]
```


```
libxslt-1.1.35       | 453 KB    | : 100% 1.0/1 [00:02<00:00,  2.08s/it]
```

```
mpfr-4.1.0           | 2.6 MB    | : 100% 1.0/1 [00:02<00:00,  4.52it/s]
```

```
llvm-openmp-14.0.6   | 4.4 MB    | : 100% 1.0/1 [00:02<00:00,  3.04s/it]
```


```
llvm-openmp-14.0.6   | 4.4 MB    | : 100% 1.0/1 [00:02<00:00,  3.04s/it]
```


```
libhwloc-2.8.0       | 3.0 MB    | : 100% 1.0/1 [00:03<00:00,  3.37s/it]
```

```
libhwloc-2.8.0       | 3.0 MB    | : 100% 1.0/1 [00:03<00:00,  3.37s/it]
```

```
 ... (more hidden) ...
```

```
pyfmi-2.9.8          | 12.7 MB   | : 100% 1.0/1 [00:05<00:00,  1.27it/s]
```

```
scipy-1.10.0         | 23.5 MB   | : 100% 1.0/1 [00:12<00:00,  1.27s/it]
```

```
icu-58.2             | 22.6 MB   | : 100% 1.0/1 [00:14<00:00,  1.50s/it]
```

```
Preparing transaction: \   |   /   done
Verifying transaction: \   |   /   -   \   |   /   done
Executing transaction: \   |   /   -   \   |   /   -   \   |   /   -   \   |   /   -   \   |   done
```

Notes of BPL_TEST2_Perfusion

This notebook explore perfusion cultivation in comparison with ordinary continuous cultivation (chemostat) and use comparable settings to earlier notebook. Further you see here examples of interaction with the simplified commands par(), init(), simu() etc as well

as direct interaction with the FMU which is called "model" here. The last simulation is always available in the workspace and called "sim_res". Note that describe() brings mainly up from descriptive information from the Modelica code from the FMU but is complemented by some information given in the Python setup file.

Now specific installation run a simulation and notebook for that Start with connecting to Github. Then upload the two files:

- FMU - BPL_TEST2_Perfusion_linux_om_me.fmu
- Setup-file - BPL_TEST2_Perfusion_explore.py

In [1]:
```
%%bash
git clone https://github.com/janpeter19/BPL_TEST2_Perfusion
```

```
bash: line 1: git: command not found
---------------------------------------------------------------------------
CalledProcessError                        Traceback (most recent call last)
Cell In[1], line 1
----> 1 get_ipython().run_cell_magic('bash', '', 'git clone https://github.com/janpeter19/BPL_TEST2_Perfusion\n')

File ~/miniconda3/envs/pyfmi/lib/python3.8/site-packages/IPython/core/interactiveshell.py:2422, in InteractiveShell.run_cell_magic(self, magic_name, line, cell)
   2420 with self.builtin_trap:
   2421     args = (magic_arg_s, cell)
-> 2422     result = fn(*args, **kwargs)
   2423 return result

File ~/miniconda3/envs/pyfmi/lib/python3.8/site-packages/IPython/core/magics/script.py:153, in ScriptMagics._make_script_magic.<locals>.named_script_magic(line, cell)
    151 else:
    152     line = script
--> 153 return self.shebang(line, cell)

File ~/miniconda3/envs/pyfmi/lib/python3.8/site-packages/IPython/core/magics/script.py:305, in ScriptMagics.shebang(self, line, cell)
    300 if args.raise_error and p.returncode != 0:
    301     # If we get here and p.returncode is still None, we must have
    302     # killed it but not yet seen its return code. We don't wait for it,
    303     # in case it's stuck in uninterruptible sleep. -9 = SIGKILL
    304     rc = p.returncode or -9
--> 305     raise CalledProcessError(rc, cell)

CalledProcessError: Command 'b'git clone https://github.com/janpeter19/BPL_TEST2_Perfusion\n'' returned non-zero exit status 127.
```

In [ ]:
```
%cd BPL_TEST2_Perfusion
```

In [23]:
```
run -i BPL_TEST2_Perfusion_explore_me.py
```

```
Linux - run FMU pre-comiled OpenModelica 1.21.0

Model for bioreactor has been setup. Key commands:
 - par()       - change of parameters and initial values
 - init()      - change initial values only
 - simu()      - simulate and plot
 - newplot()   - make a new plot
 - show()      - show plot from previous simulation
 - disp()      - display parameters and initial values from the last sim
ulation
 - describe()  - describe culture, broth, parameters, variables with val
ues / units

Note that both disp() and describe() takes values from the last simulati
on

Brief information about a command by help(), eg help(simu)
Key system information is listed with the command system_info()
<Figure size 984.252x787.402 with 0 Axes>
```

In [24]:
```
%matplotlib inline
plt.rcParams['figure.figsize'] = [25/2.54, 20/2.54]
```

In [25]:
```
# Process parameters used throughout
par(Y=0.5, qSmax=0.75, Ks=0.1)                                  # Cul
par(filter_eps=0.10, filter_alpha_X=0.02, filter_alpha_S=0.10)  # Fil
par(S_in=30.0)                                                  # Inl
init(V_0=1.0, VX_0=1.0)                                         # Prc
eps = parDict['filter_eps']                                     # Pum
```

In [26]:
```
parDict
```

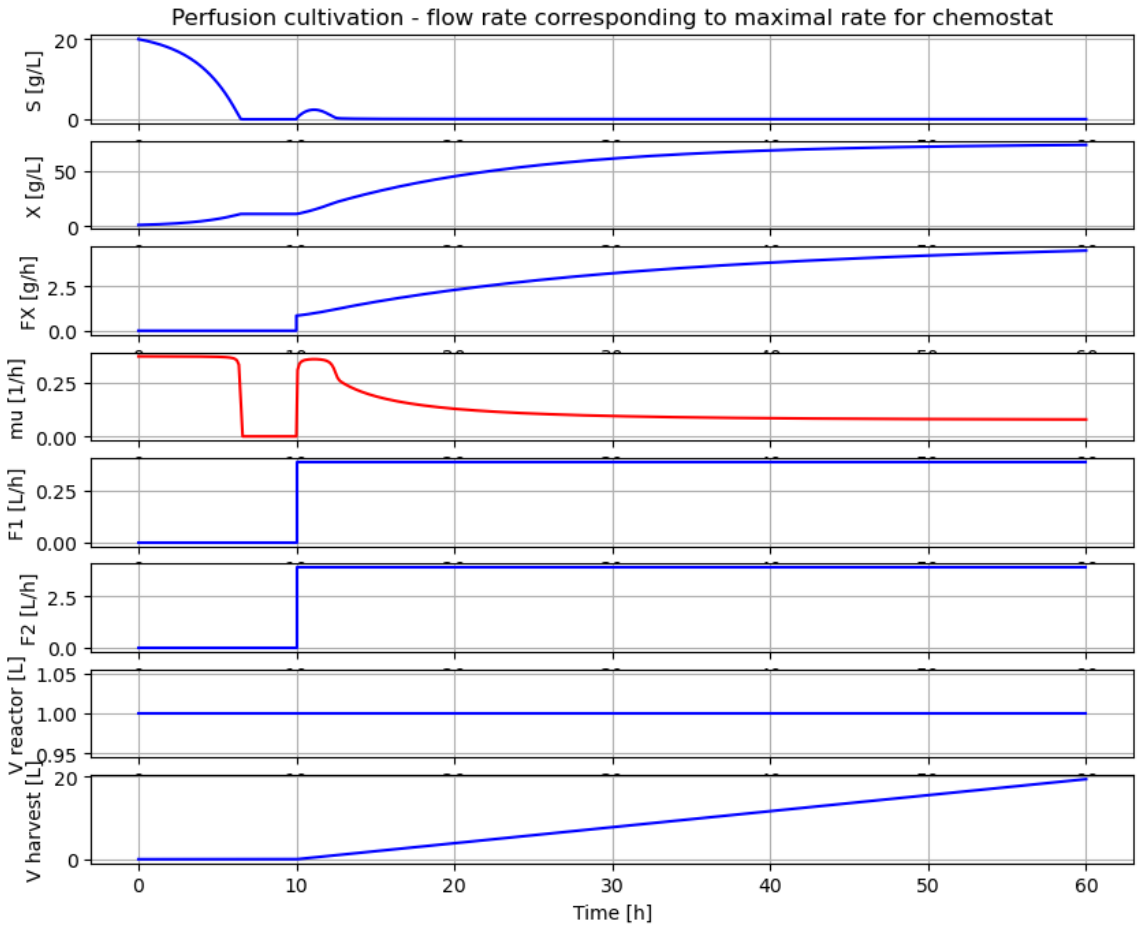
Out[26]:
```
{'V_0': 1.0,
 'VX_0': 1.0,
 'VS_0': 100.0,
 'Y': 0.5,
 'qSmax': 0.75,
 'Ks': 0.1,
 'filter_eps': 0.1,
 'filter_alpha_X': 0.02,
 'filter_alpha_S': 0.1,
 'S_in': 30.0,
 'harvesttank_V_0': 0.0,
 'harvesttank_X_0': 0.0,
 'harvesttank_S_0': 0.0,
 'pump1_t0': 0.0,
 'pump1_F0': 0.0,
 'pump1_t1': 17.0,
 'pump1_F1': 4.0,
 'pump1_t2': 50.0,
 'pump1_F2': 4.0,
 'pump1_t3': 993.0,
 'pump1_F3': 4.0,
 'pump1_t4': 994.0,
 'pump1_F4': 4.0,
 'pump2_t0': 0.0,
 'pump2_F0': 0.0,
 'pump2_t1': 17.0,
 'pump2_F1': 4.0,
 'pump2_t2': 50.0,
 'pump2_F2': 4.0,
 'pump2_t3': 993.0,
 'pump2_F3': 4.0,
 'pump2_t4': 994.0,
 'pump2_F4': 4.0}
```

In [27]:
```
# Simulation of process with flow rate clot to wash-out for chemostat

init(VS_0=20)                                                    # Process initia
par(pump1_t1=10, pump2_t1=10)                                    # Pump schedule
par(pump1_F1=2.5*0.155, pump2_F1=2.5*0.155/eps)
par(pump1_t2=940, pump2_t2=940, pump1_t3=950, pump2_t3=950, pump1_t4=960,

newplot(title='Perfusion cultivation - flow rate corresponding to maximal
simu(60)
```

```
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
```



In [28]:
```
# Concentration factor of the filter
c=model.get('filter.retentate.c[1]')[0]/model.get('filter.inlet.c[1]')[0]
print('Conc factor of perfusion filter =', np.round(c,3))
```

```
Conc factor of perfusion filter = 1.089
```

In [29]:
```
c_data=sim_res['filter.retentate.c[1]']/sim_res['filter.inlet.c[1]']
print('Conc factor variation', np.round(min(c_data[151:]), 3), np.round(m
```

```
Conc factor variation 1.089 1.089
/tmp/ipykernel_3163/3491953895.py:1: RuntimeWarning: invalid value encou
ntered in divide
  c_data=sim_res['filter.retentate.c[1]']/sim_res['filter.inlet.c[1]']
```

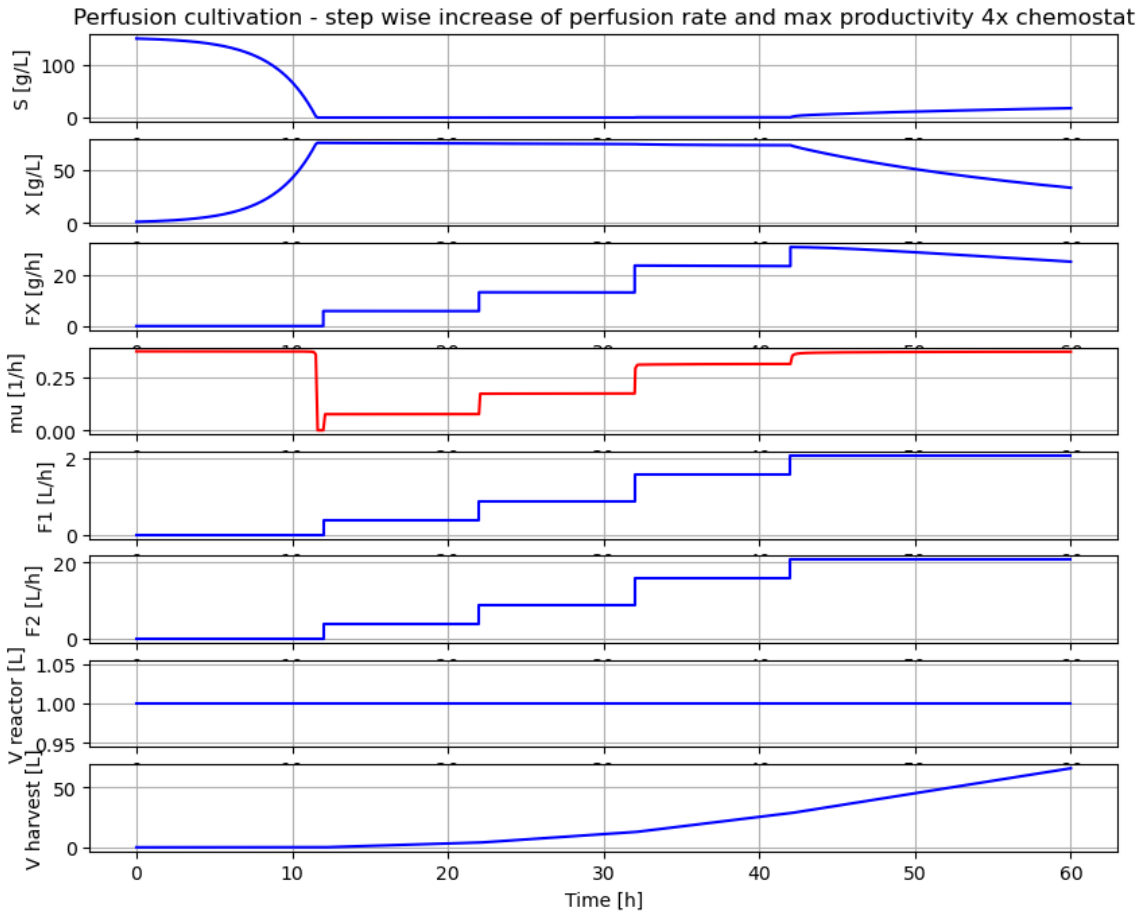
In [30]:
```
# Simulation of process with step-wise increase of pefusion rate until wa
# This means that re-circulation rate change at the same time as the perf

init(VS_0=150)                                          # Process initia

par(pump1_t1=12, pump2_t1=12)                           # Pump schedule
par(pump1_F1=2.5*0.155, pump2_F1=2.5*0.155/eps)
par(pump1_t2=22, pump2_t2=22)
par(pump1_F2=2.5*0.35, pump2_F2=2.5*0.35/eps)
par(pump1_t3=32, pump2_t3=32)
par(pump1_F3=2.5*0.63, pump2_F3=2.5*0.63/eps)
par(pump1_t4=42, pump2_t4=42)
par(pump1_F4=2.5*0.83, pump2_F4=2.5*0.83/eps)

newplot(title='Perfusion cultivation - step wise increase of perfusion ra
simu(60)
```

```
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
```



In [31]:
```
# Simulation without a plot and just to check typical values at high proc
simu(40)
c_data=sim_res['filter.retentate.c[1]']/sim_res['filter.inlet.c[1]']
print('Conc factor variation', np.round(min(c_data[190:]), 3), 'to', np.r
```

```
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
stdout            | warning | The default linear solver fails, the fallb
ack solver with total pivoting is started at time 0.000000. That might r
aise performance issues, for more information use -lv LOG_LS.
Conc factor variation 1.089 to 1.089
```

```
/tmp/ipykernel_3163/3195256660.py:3: RuntimeWarning: invalid value encou
ntered in divide
  c_data=sim_res['filter.retentate.c[1]']/sim_res['filter.inlet.c[1]']
```

In [32]:
```
#describe('cstrProdMax')
```

In [33]:
```
# The maximal biomass productivity before washout is obtained aroudn 40 h
np.round(model.get('harvesttank.inlet.F')[0]*model.get('harvesttank.inlet
```

Out[33]: 23.5

In [34]:
```
# Thus perfusion (with this filter) brings a productivity improvement of
np.round(23.5/5.6,1)
```

Out[34]: 4.2

In [35]:
```
# Finally we check the filter flow rates at time 40 hour - note the negat
model.get('filter.inlet.F')[0]
```

Out[35]: 15.749999999999998

In [36]:
```
model.get('filter.filtrate.F')[0]
```

Out[36]: -1.575

In [37]:
```
model.get('filter.retentate.F')[0]
```

Out[37]: -14.174999999999999

Summary

- The perfusion filter had a concentration factor of cells around 1.08 and re-cycling flow was set to a factor 10 higher than the perfusion rate and changed when perfusion rate was change to keep the ratio factor 10.
- The first simulation showed that by cell retention using perfusion filter the process could be run at a perfusion flow rate at the maximal flow rate possible for corresponding chemostat culture and cell concetration increased steadily.
- The second simulation showed that with a proper startup cell concentration, the cell concentration remained constant when perfusion rate increased in a similar way as what we see in a chemostat.
- The second simulation also showed that biomass productivity in this case was increased by a factor 4.2 compared to chemostat.
- If the perfusion rate increased to higher levels washout started but the decrase of cell concentration was slow.

Some of you who read this may have your perfusion experience with CHO-cultures. For such cultures the cell concentration do increase with increase of perfusion rate and there are understood reasons for that. But for this simplifed process as well as microbial processes they typically keep cell concentration constant when flow rate is chaged, and that under quite wide conditions. I will try come back to this phenomena in a later notebook.

In [38]:
```
# List of components in the process setup and also a couple of other thir
describe('parts')
```

```
['bioreactor', 'bioreactor.culture', 'D', 'feedtank', 'filter', 'harvest
tank', 'schemePump1', 'schemePump2']
```

In [39]:
```
describe('MSL')
```

```
MSL: 3.2.3 - used components: RealInput, RealOutput, CombiTimeTable, Typ
es
```

In [40]:
```
system_info()
```

```
System information
 -OS: Linux
 -Python: 3.8.16
 -Scipy: not installed in the notebook
 -PyFMI: 2.9.8
 -FMU by: OpenModelica Compiler OpenModelica 1.21.0~dev-185-g9d983b8
 -FMI: 2.0
 -Type: FMUModelME2
 -Name: BPL_TEST2.Perfusion
 -Generated: 2023-01-25T11:02:31Z
 -MSL: 3.2.3
 -Description: Bioprocess Library version 2.1.1-beta
 -Interaction: FMU-explore version 0.9.6
```

In [ ]:
```
```