# Files

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| No. | Name | Type | Description |
| 1 | CSTR\_Bioreactor.p | Simulink Block | Black-box bioreactor model. |
| 2 | CSTR\_Bioreactor\_2023.slx | Simulink | FOPTD fitting and parameters. |
| 3 | CSTR\_Bioreactor\_2023\_CohenCoon.slx | Simulink | PI control with Cohen Coon parameters. Switches activate tuning at 150h. |
| 4 | FOPTD\_Absolute.mlx | Matlab | Interacts with 2. Iterates through absolute step changes [-100, 100] and outputs time constant, time delay, and process gain. |
| 5 | FOPTD\_Percentage.mlx | Matlab | Interacts with 2. Iterates through percentage step changes [-0.2, 0.2] and outputs time constant, time delay, and process gain. |
| 6 | Testing.mlx | Matlab | Debugging file with plots. |
| 7 | out | Folder | Output folder for FOPTD spreadsheets from Matlab. |
| 8 | pdc\_project | Folder | Python package. |
| 9 | pyproject.toml | Python | Python environment. |
| 10 | environment.yml | Python | Python environment. |
| 11 | FOPTD.ipynb | Python | Jupyter notebook with meta-analysis of step. |
| 12 | Control Project Brief 2023.pdf | PDF | Project brief. |

# Version Control

Files are in a private repository on GitHub (d21@ic.ac.uk).

# Typesetting

1. Share all documents in the OneDrive folder
2. Please use this [link](https://www.overleaf.com/1648684298qwsmgsgyxghj) to access Overleaf

# Diagram, schematic Description automatically generated­Nominal values

# Explanations

## ­FOPTD

Let the steady state value before step change be s\_1, the steady state value after step change be s\_2, the step time be s\_t, and values at the steepest tangent denoted by subscript s.

1. Load Simulink using Matlab, set before and after values for step change, and simulate. Using Matlab allows us to loop through multiple step sizes.
2. Read value and derivative output from Simulink, obtaining initial steady state (200h) and final steady state (400h) values too.
3. Get maximum gradient and time from derivative (see figure).
4. Get value at time of maximum gradient (see figure).
5. Using value, time, and gradient and using y = d\_s(t-t\_s) + v\_s, calculate t at steady states 1 and 2 (t\_1 and t\_2) from y for the steady state values (see figure).
6. Get time delay (t\_1 – s\_t).
7. Get time constant (t\_2 – t\_1).
8. Get process gain by dividing (s\_1 – s\_2) with step size.
9. Tabulate the process gain, time delay, and time constant against step size.

Chart

Description automatically generatedChart, line chart

Description automatically generated

## Control

1. Control is activated at 150h using a switch block

Diagram

Description automatically generated

* 1. If clock reads > 150h, input is error so feedback control
  2. If clock reads < 150h, input is zero so control is not activated