

# AI 4 Closed-Loop Control Systems – Hackathon 2020 in Osnabrück



10.-12.01.2020



# Schedule Starting Session

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- Welcome Osnabrück University
- Welcome ZF
- Introduction of the task and damper systems by ZF experts
- Applied signal processing on the released data sets
- Organizational matters
  - Time table of the weekend
  - Room assignment
  - Helping hands
  - Q and A session
  - IT issues
  - etc.

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# Introduction of the task and damper systems by ZF experts

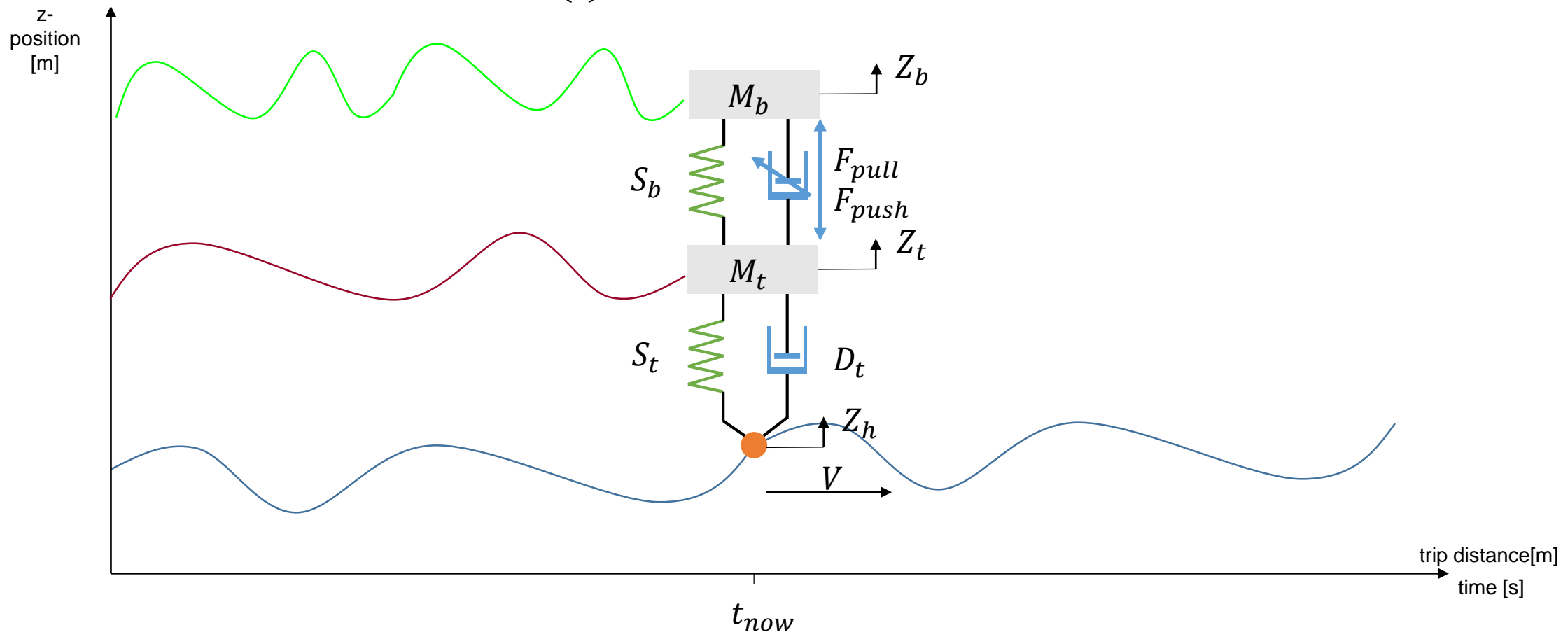


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# Applied Signal processing on the released data sets

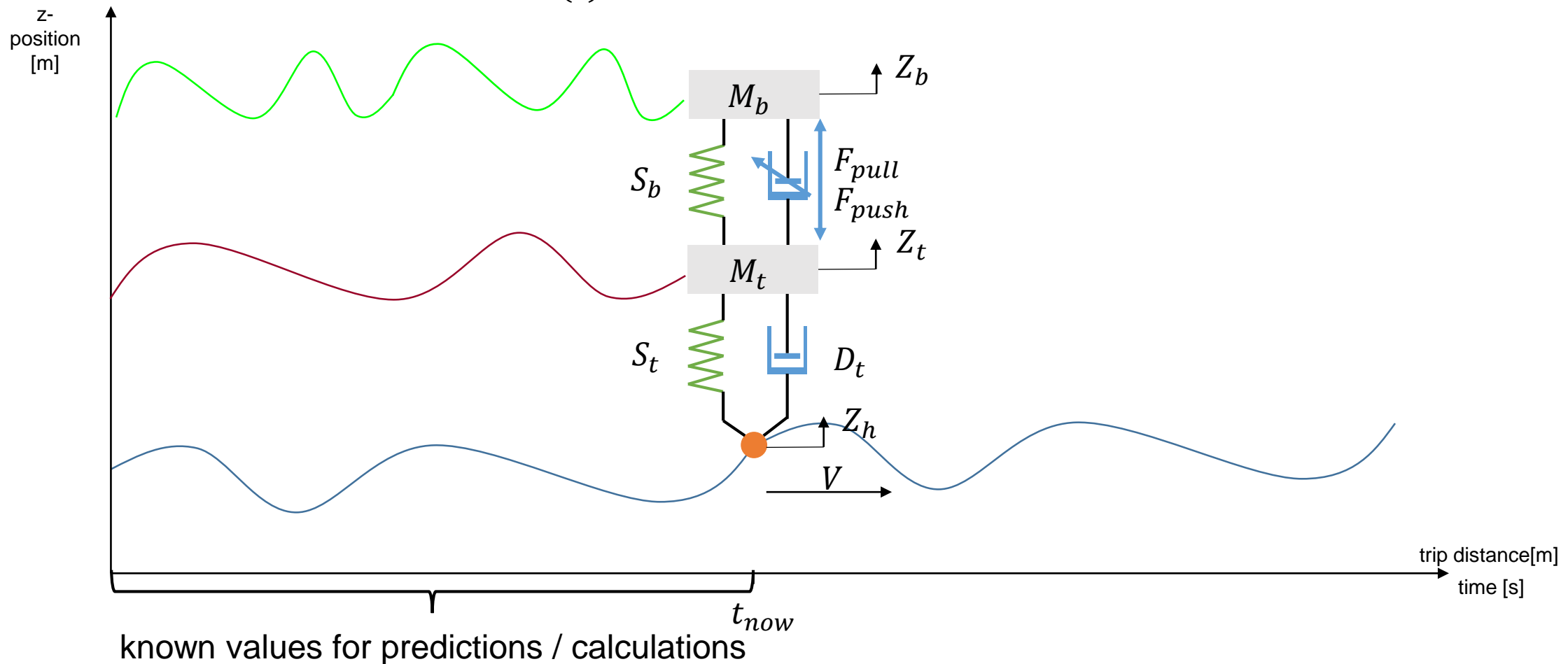
# NOT looking into the future!

- for the task you can not look into the future
  - thus only use  $data_{(t)}$  where  $t \leq t_{now}$



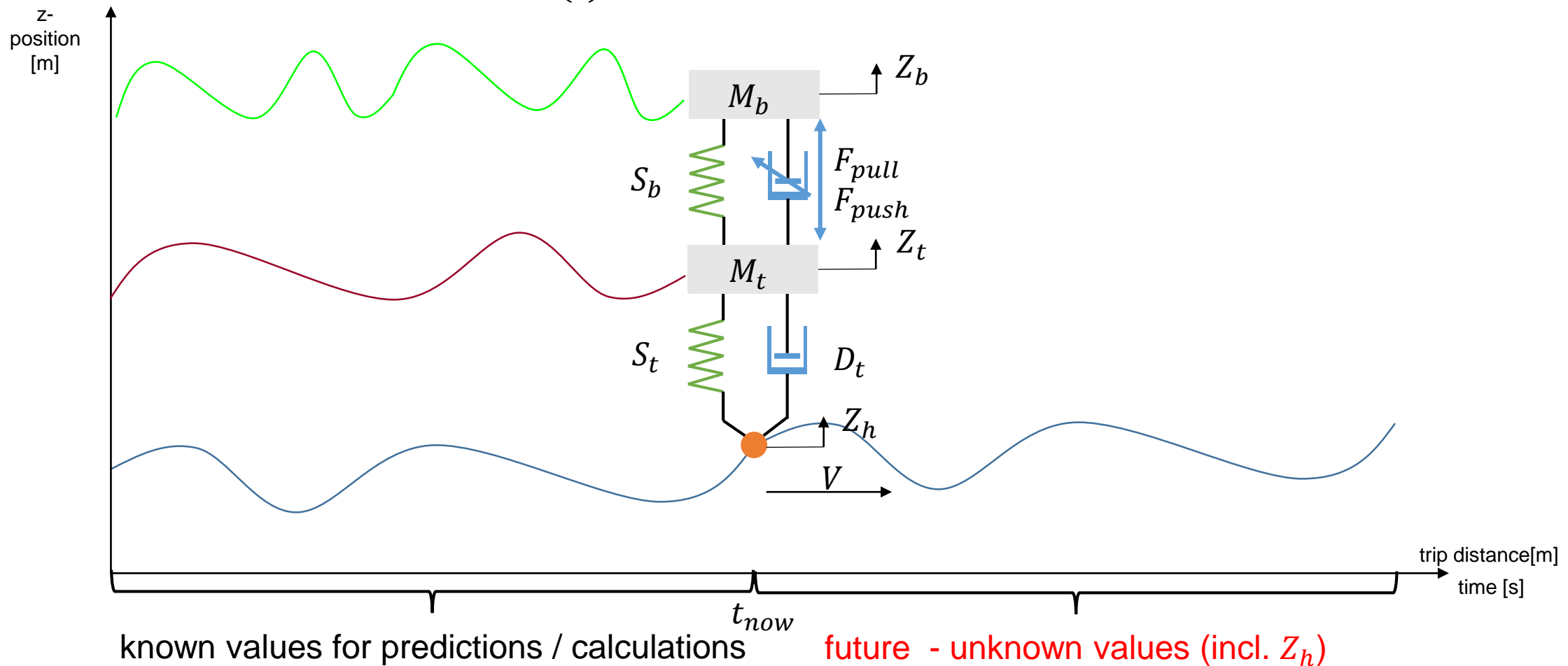
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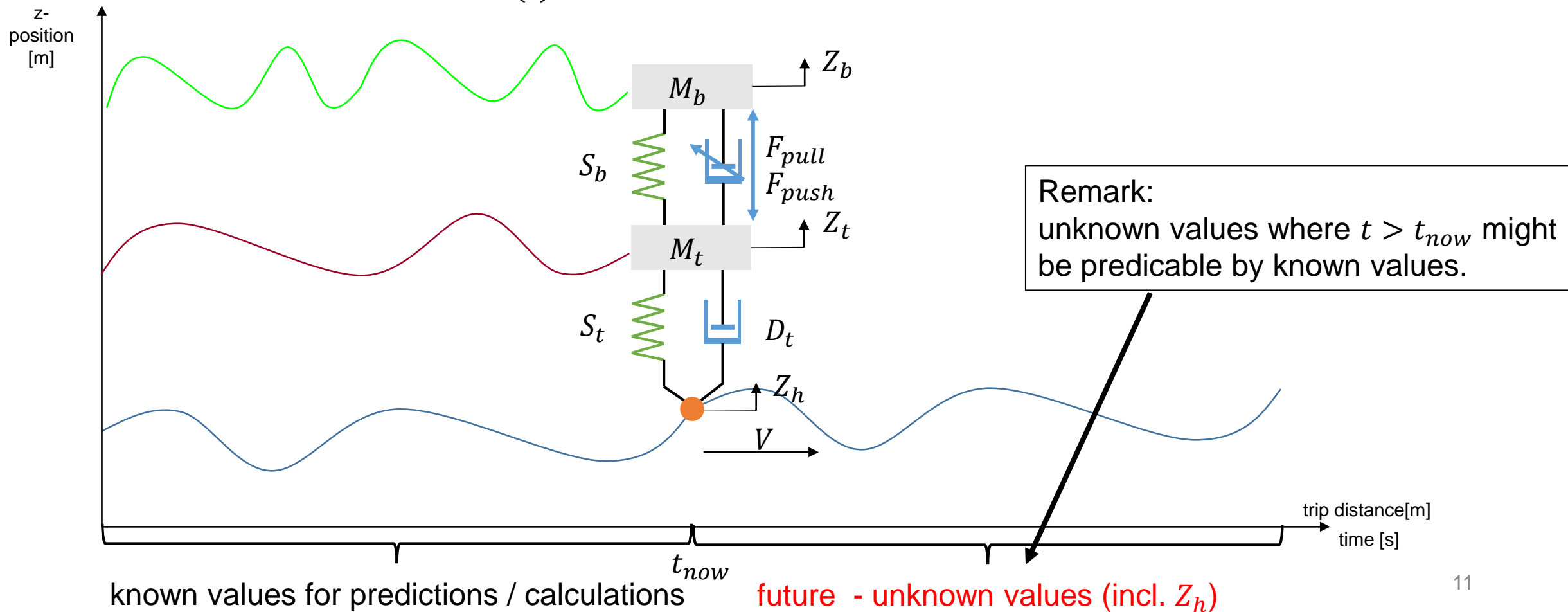
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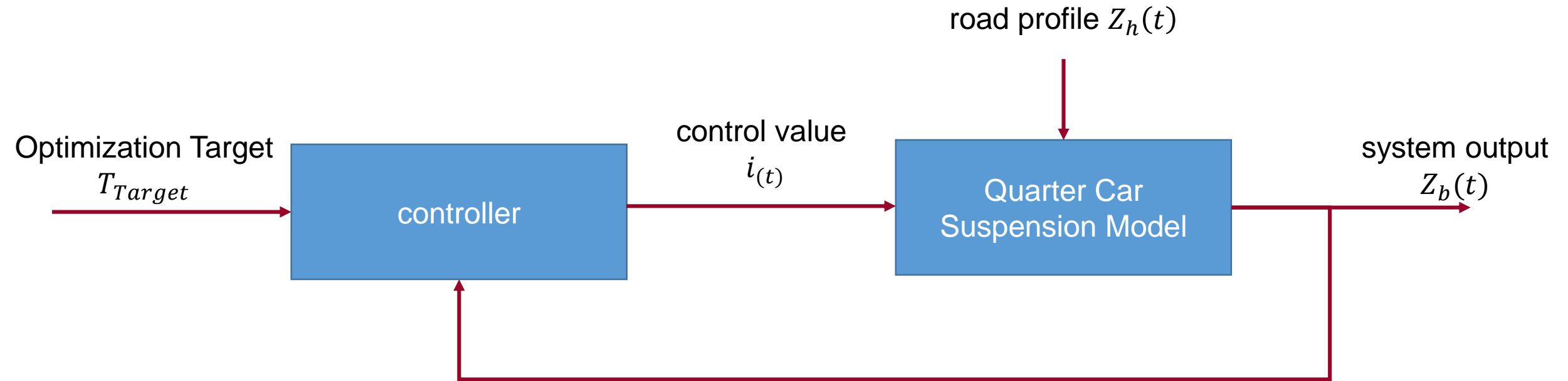
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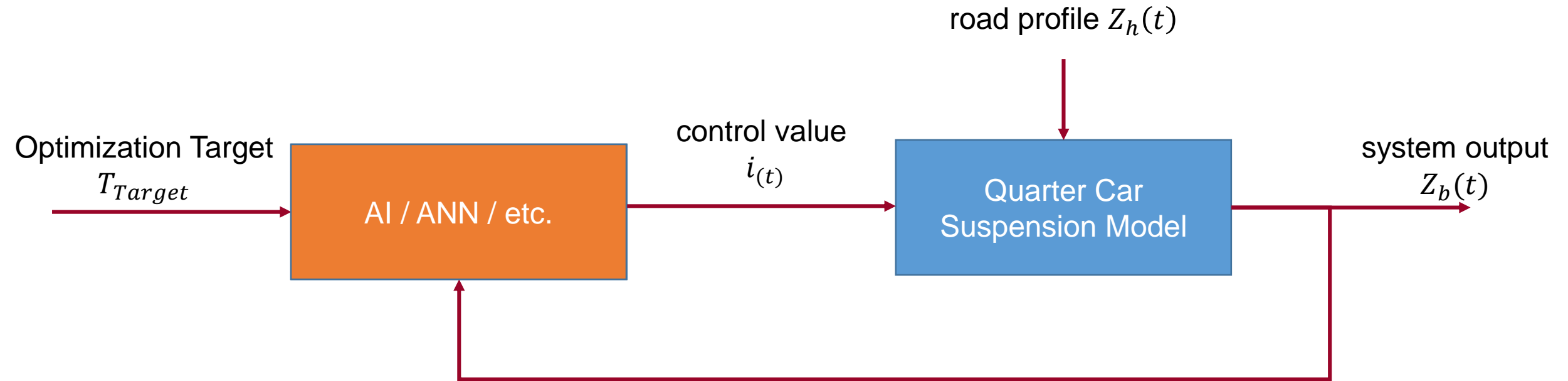




# Some information about closed-loop systems



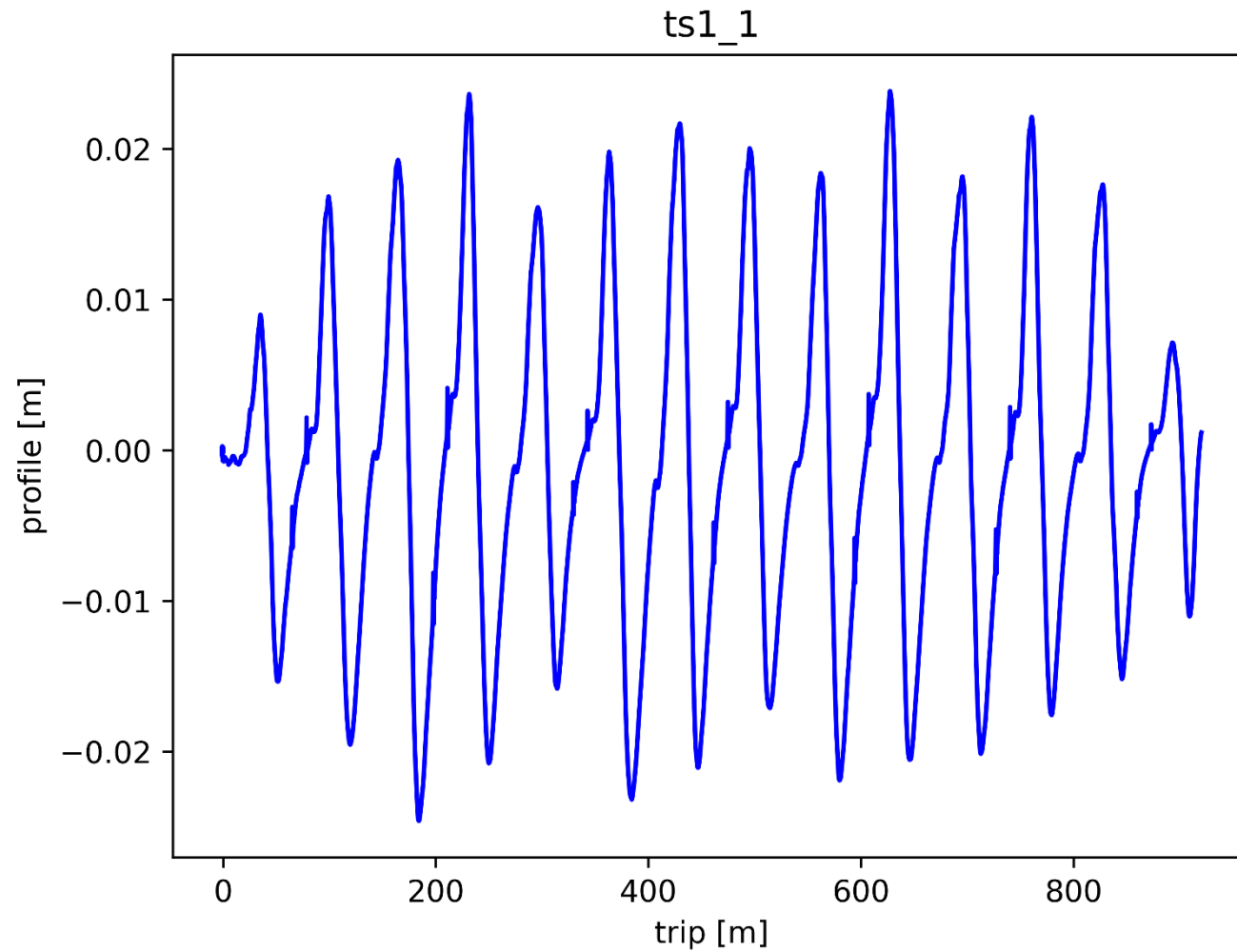
# Some information about closed-loop systems



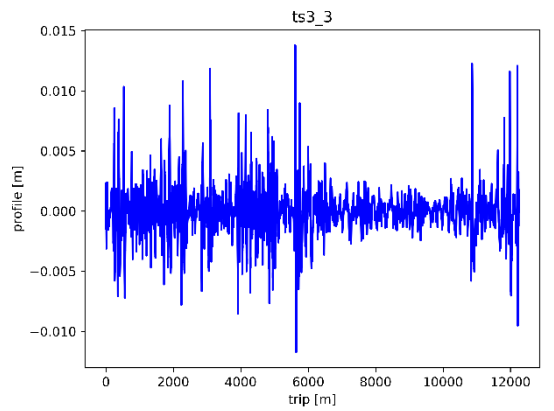
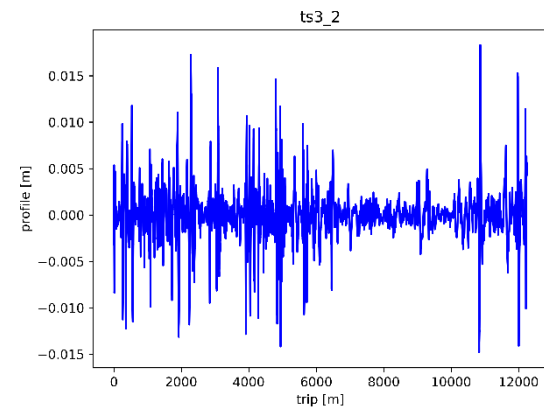
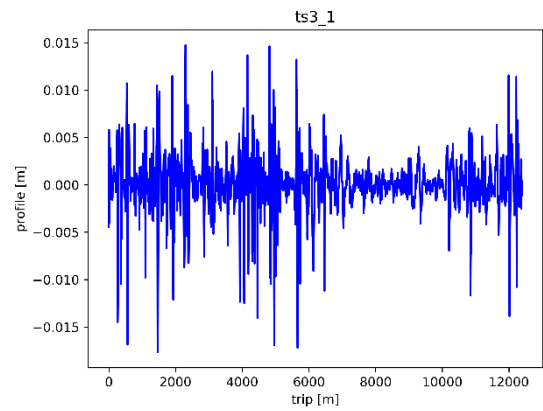
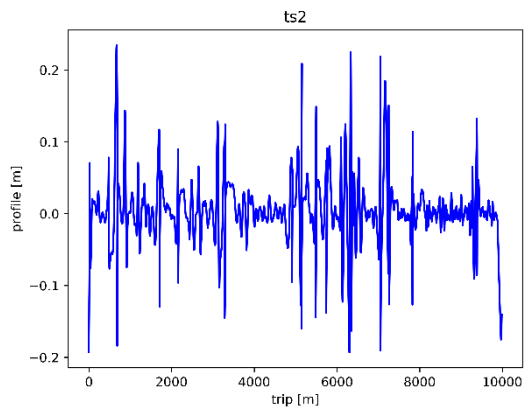
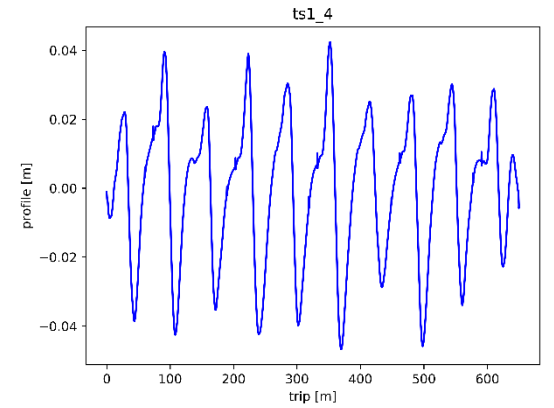
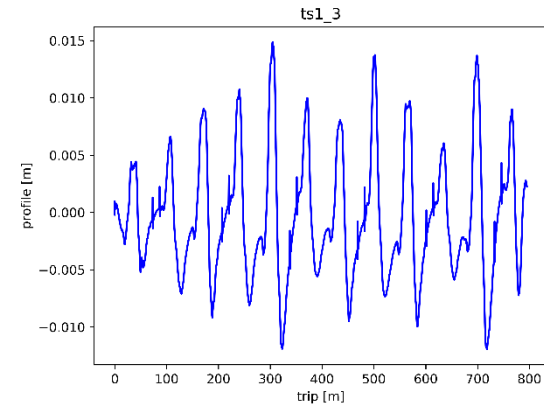
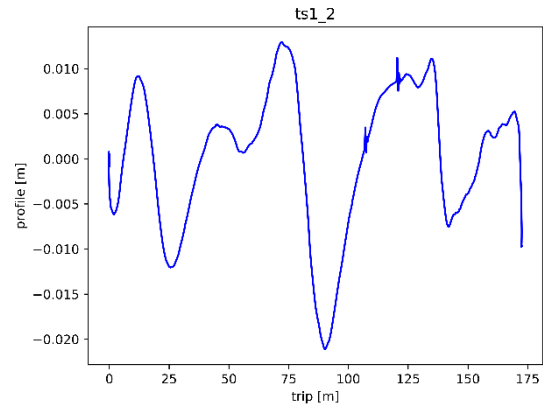
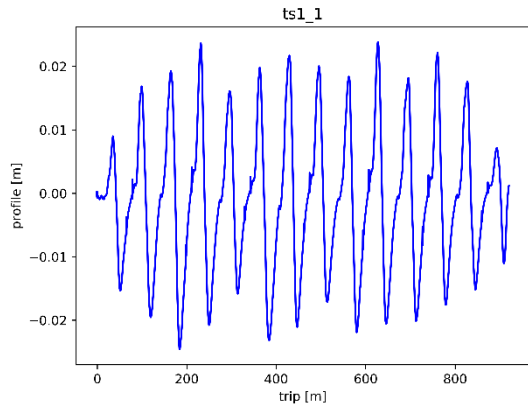
# Data sets

- All data set for the hackathon are located at:  
/net/projects/scratch/winter/valid\_until\_31\_July\_2020/hackathon/datasets
  - 9 different data set are provided
    - ts1\_1\_k\_3.0.csv
    - ts1\_2\_k\_3.0.csv
    - ts1\_3\_k\_3.0.csv
    - ts1\_4\_k\_3.0.csv
    - ts2\_k\_20.0.csv
    - ts3\_1\_k\_3.0.csv
    - ts3\_2\_k\_3.0.csv
    - ts3\_3\_k\_3.0.csv
    - ts4\_k\_???.csv
- released by now
- released on Sunday by 17:00 for the final evaluation

# Data sets – example ts1\_1

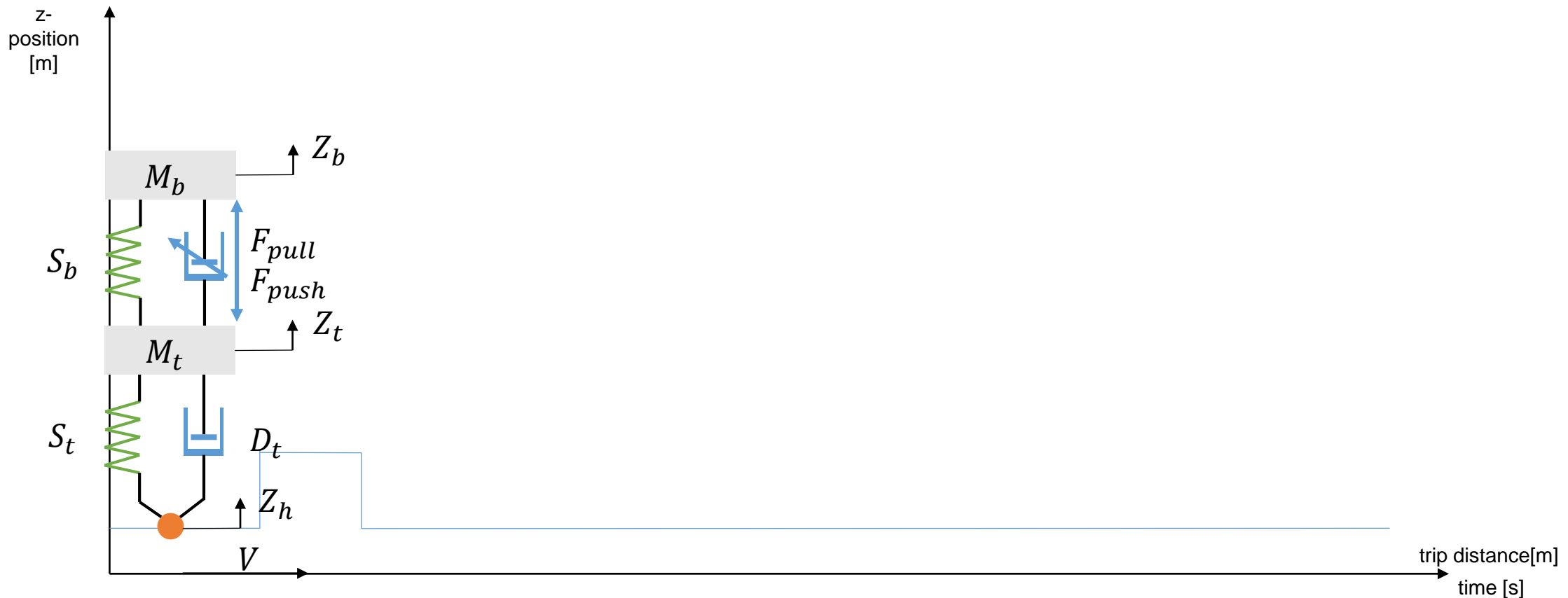


# Data sets – Overview



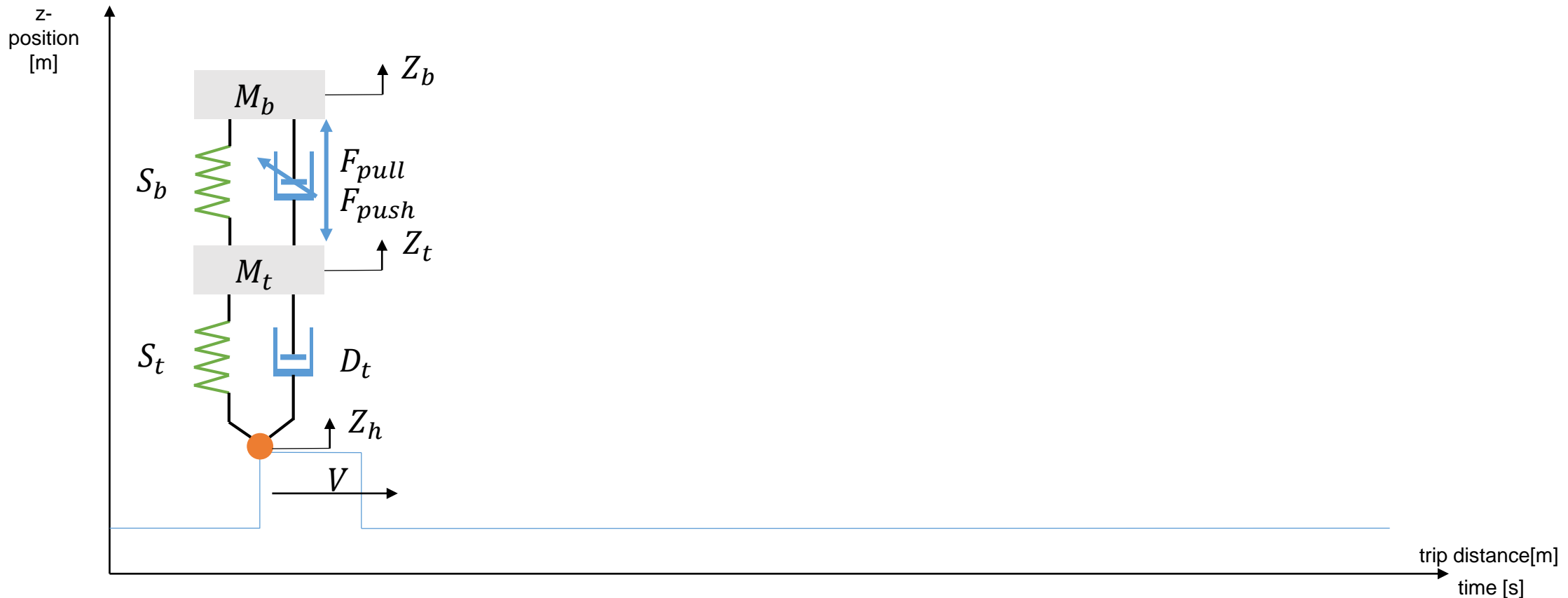
# Example Speed Bump

- rectangular speed bump is one extreme case
  - it is a theoretical case such speed bumps do not exist



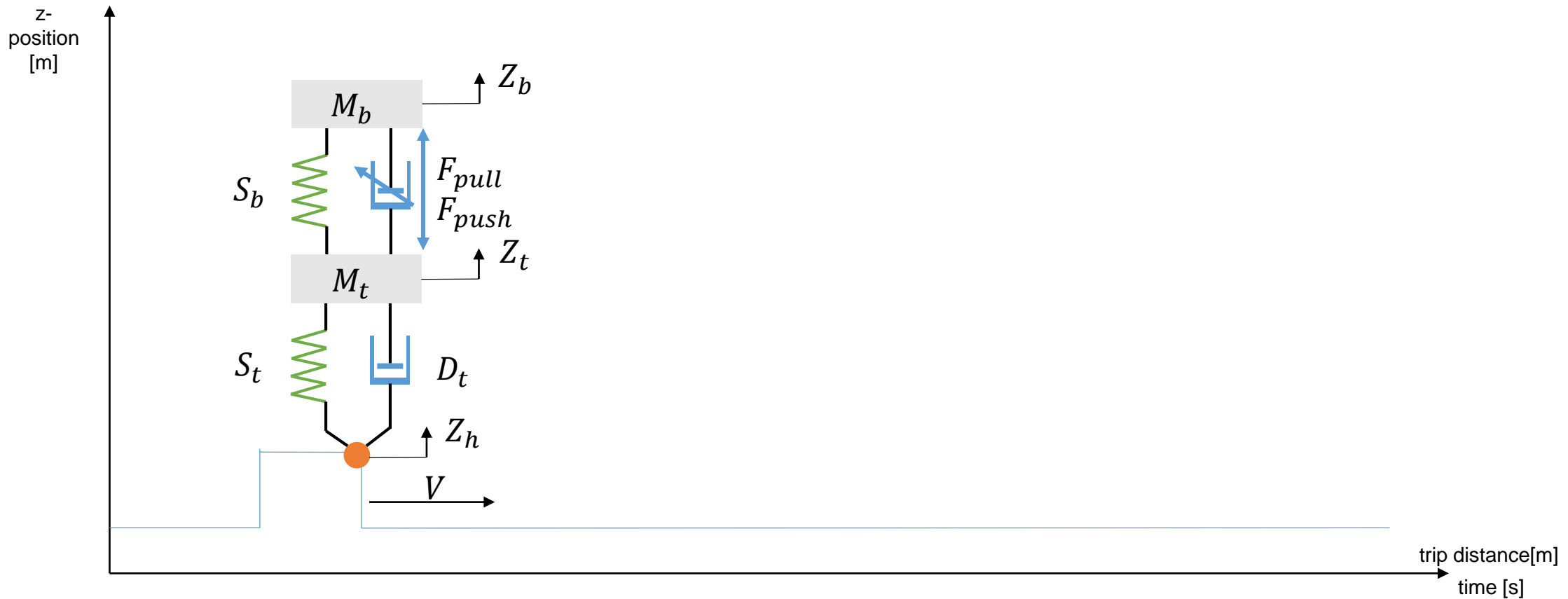
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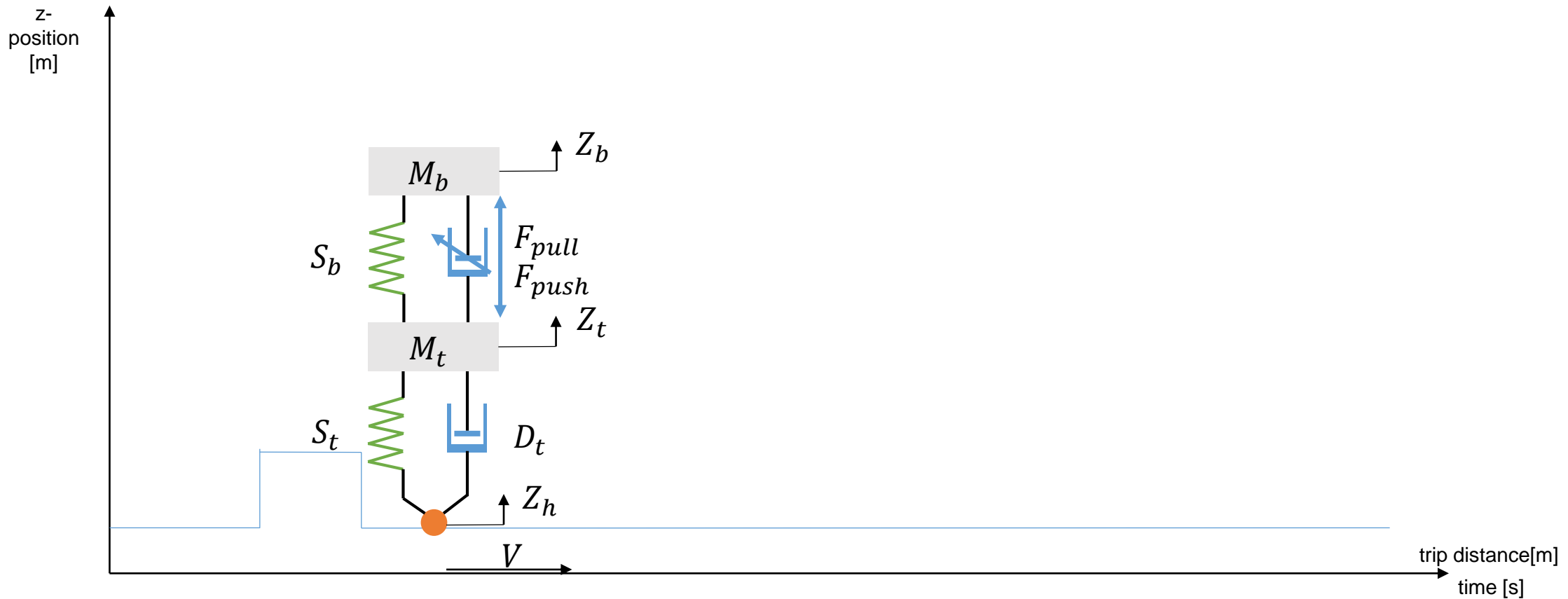
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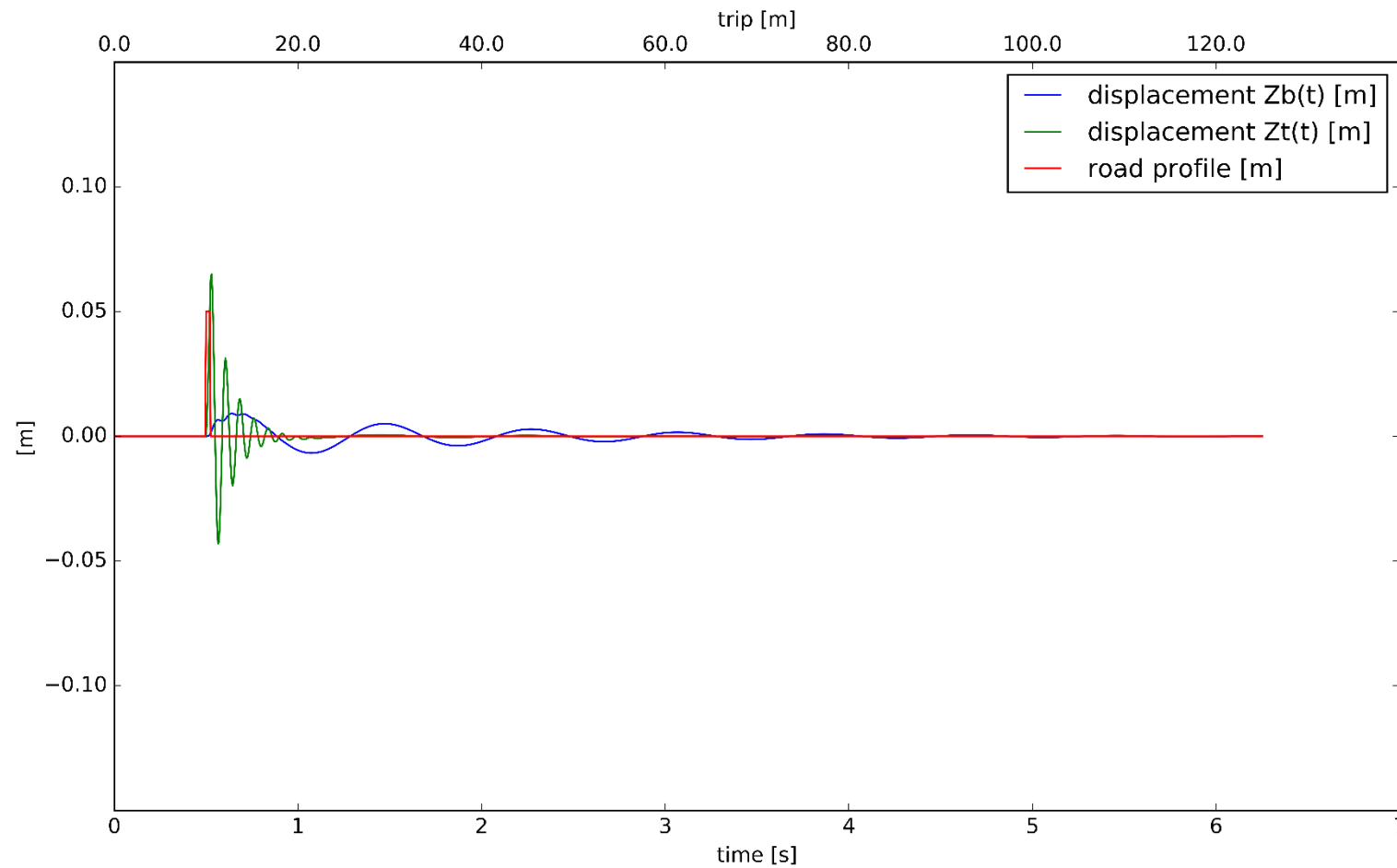


# Example Speed Bump

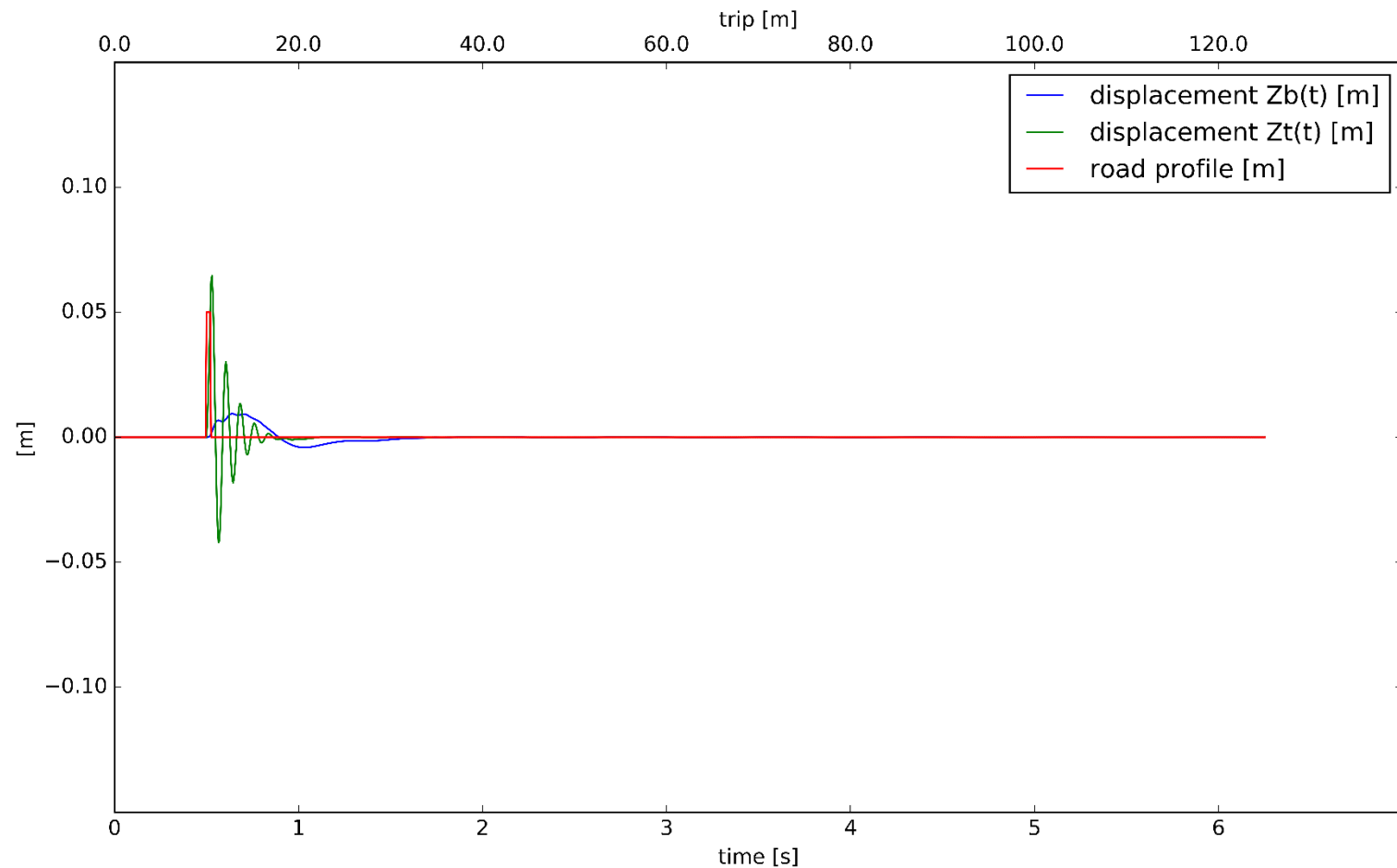
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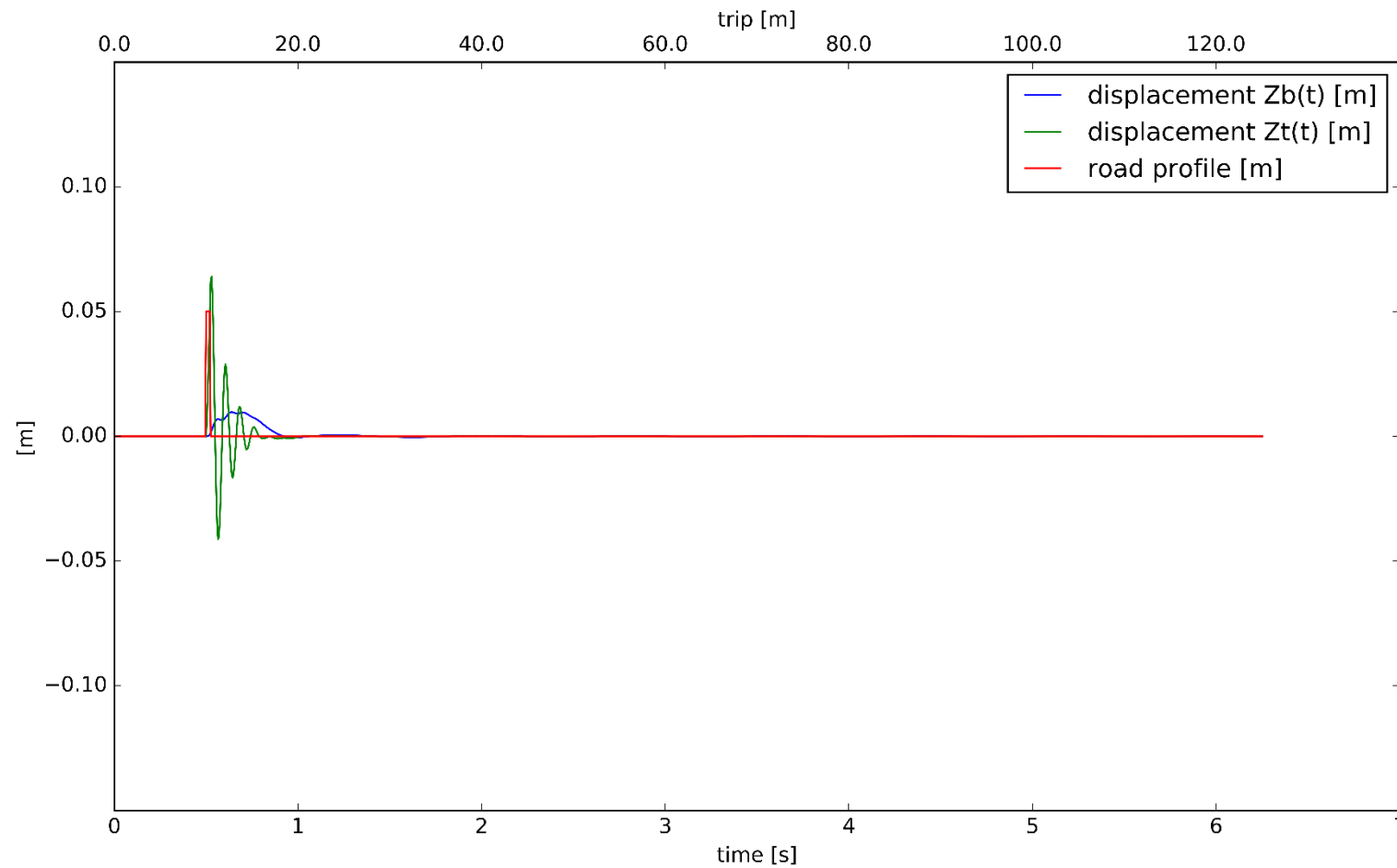
# Example Speed Bump – Simulation – $i_{const} = 0.0A$



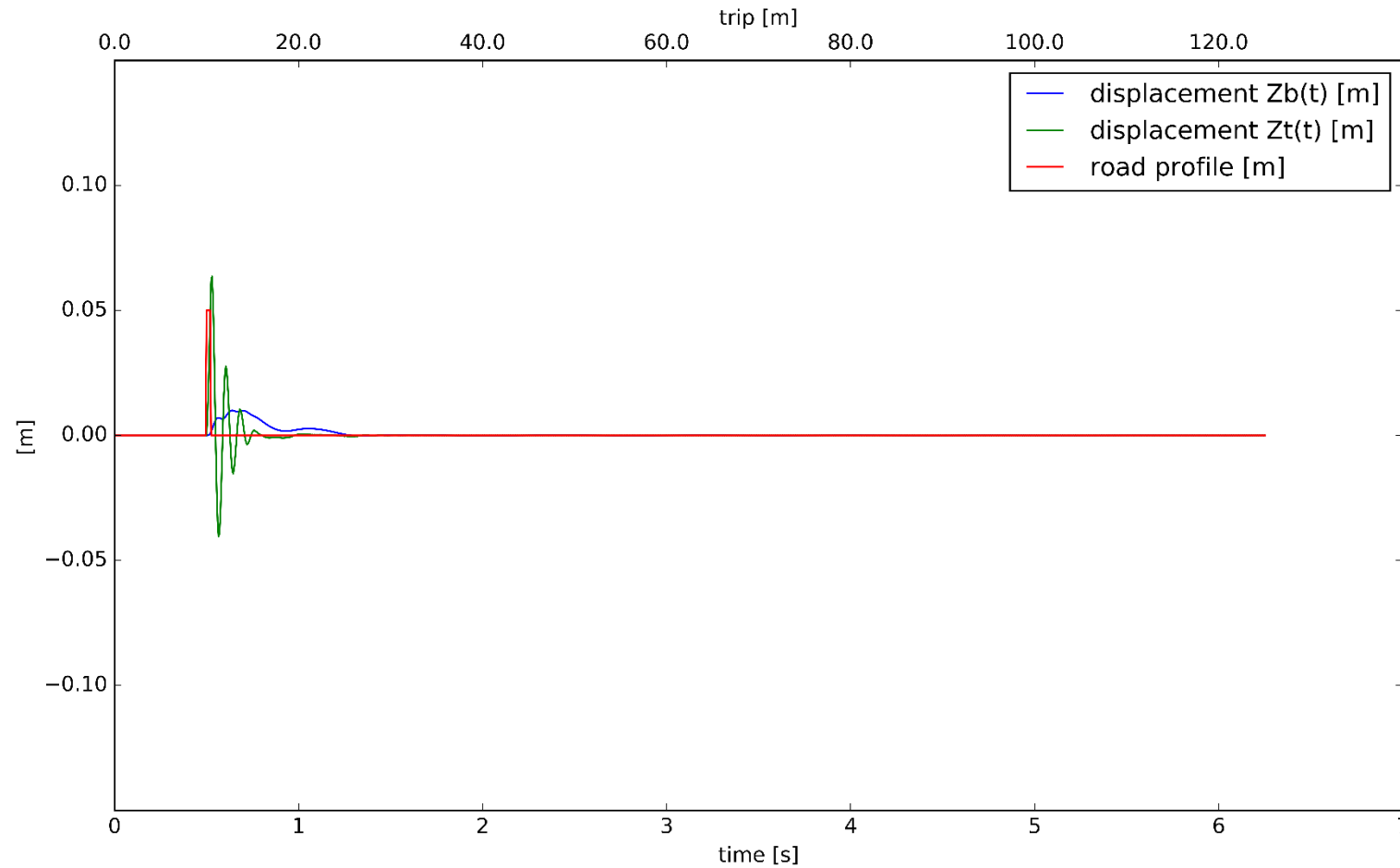
# Example Speed Bump – Simulation – $i_{const} = 0.2A$



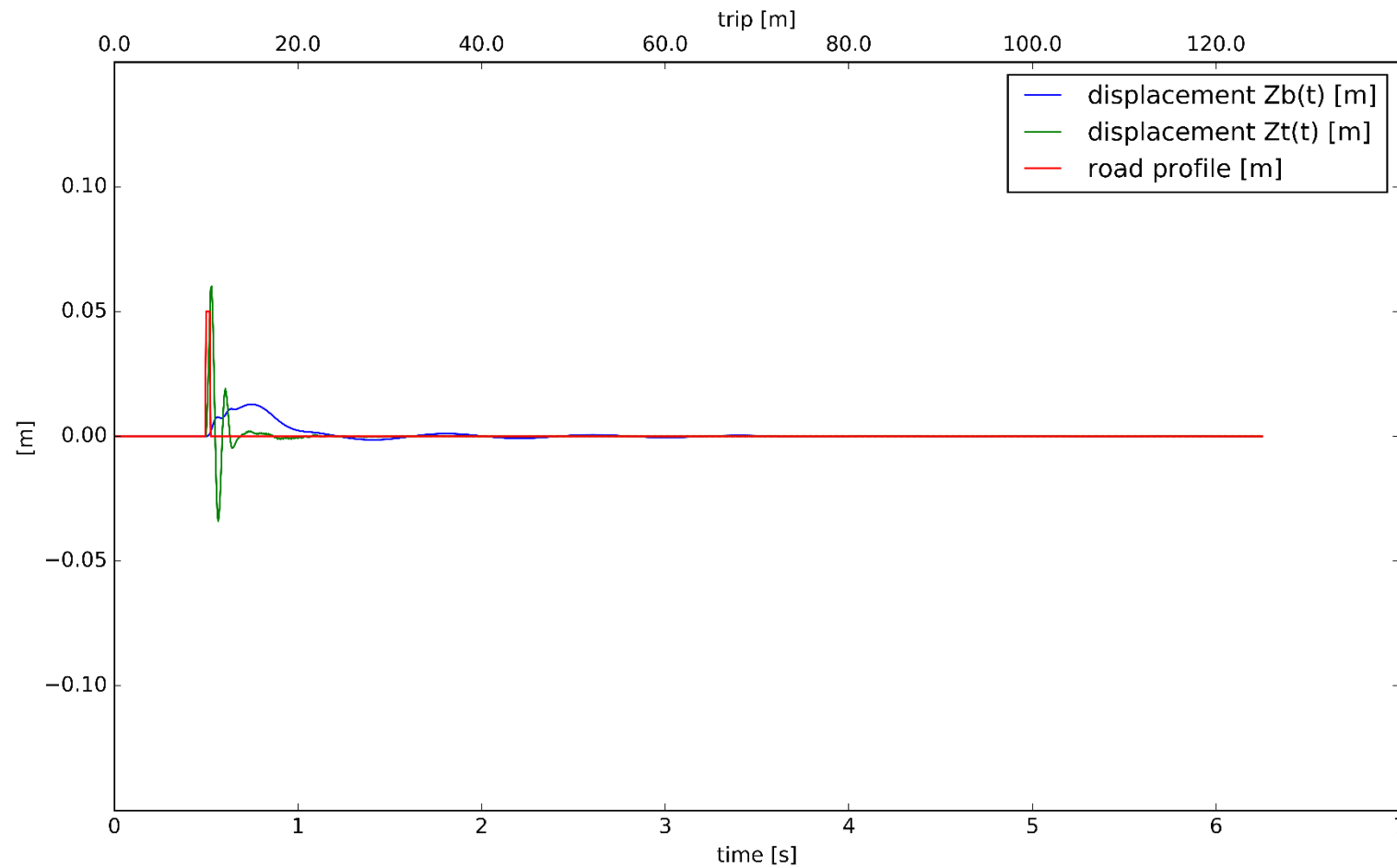
# Example Speed Bump – Simulation – $i_{const} = 0.4A$



# Example Speed Bump – Simulation – $i_{const} = 0.6A$

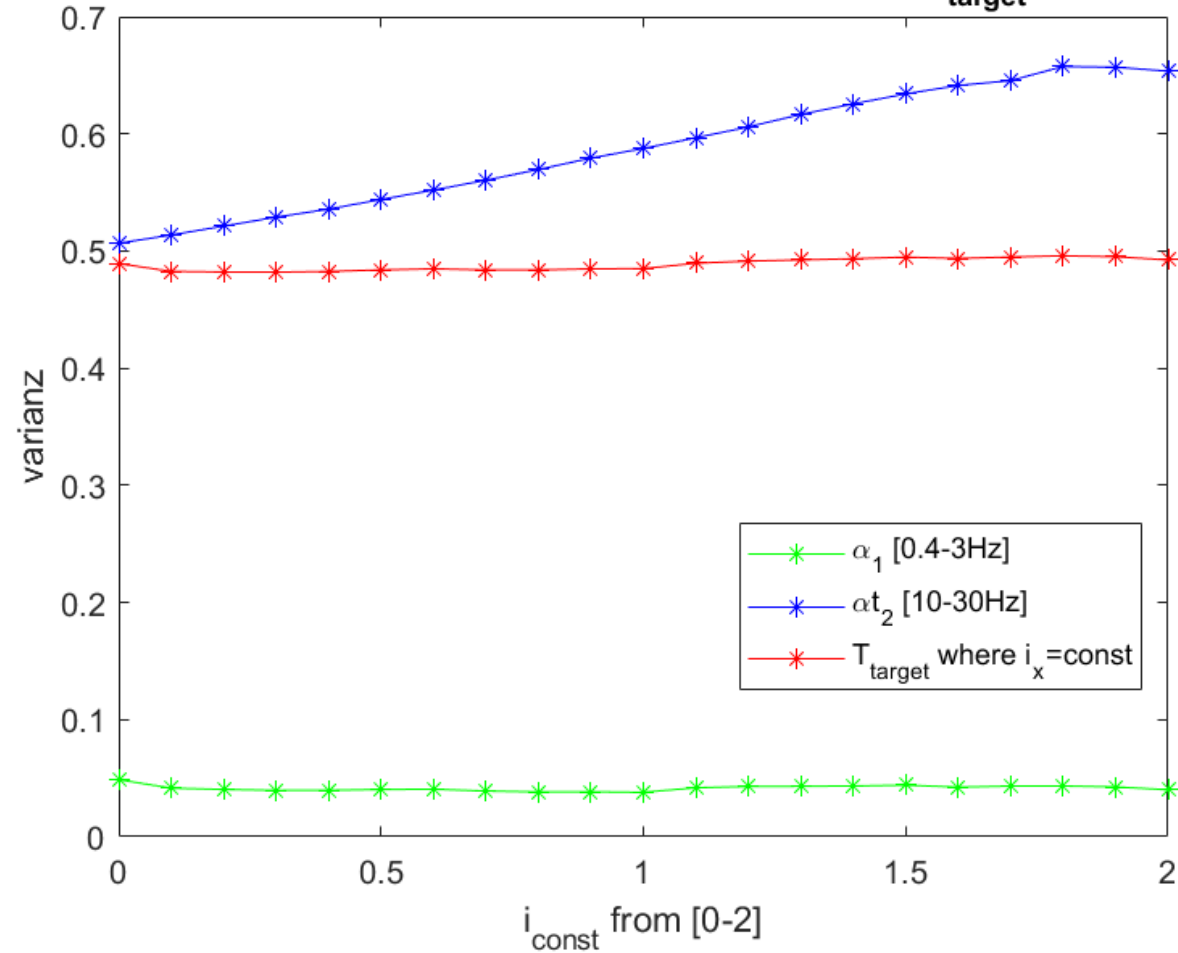


# Example Speed Bump – Simulation – $i_{const} = 2.0A$



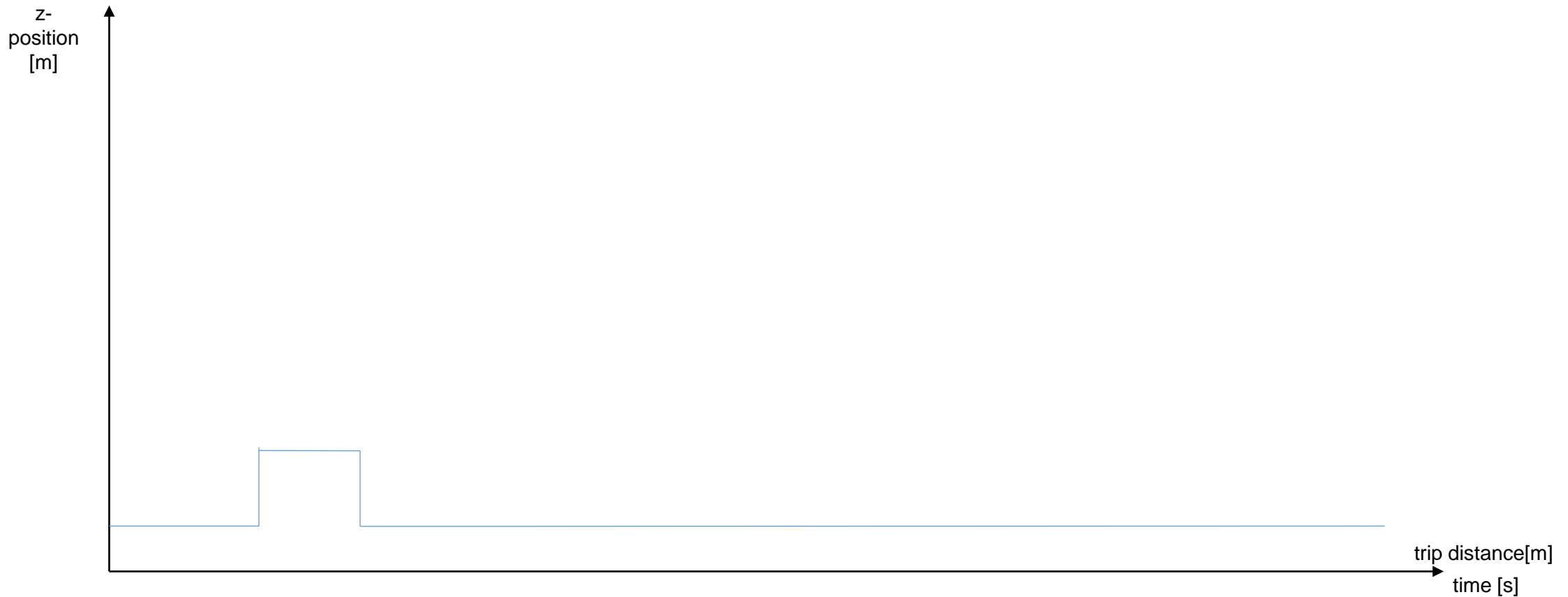
# Example Speed Bump – Simulation – $i_{const}$

Non dynamic damper activation on speed bump;  $v=20$ ;  $T_{target}$  shifted by +0.2



# Example Speed Bump

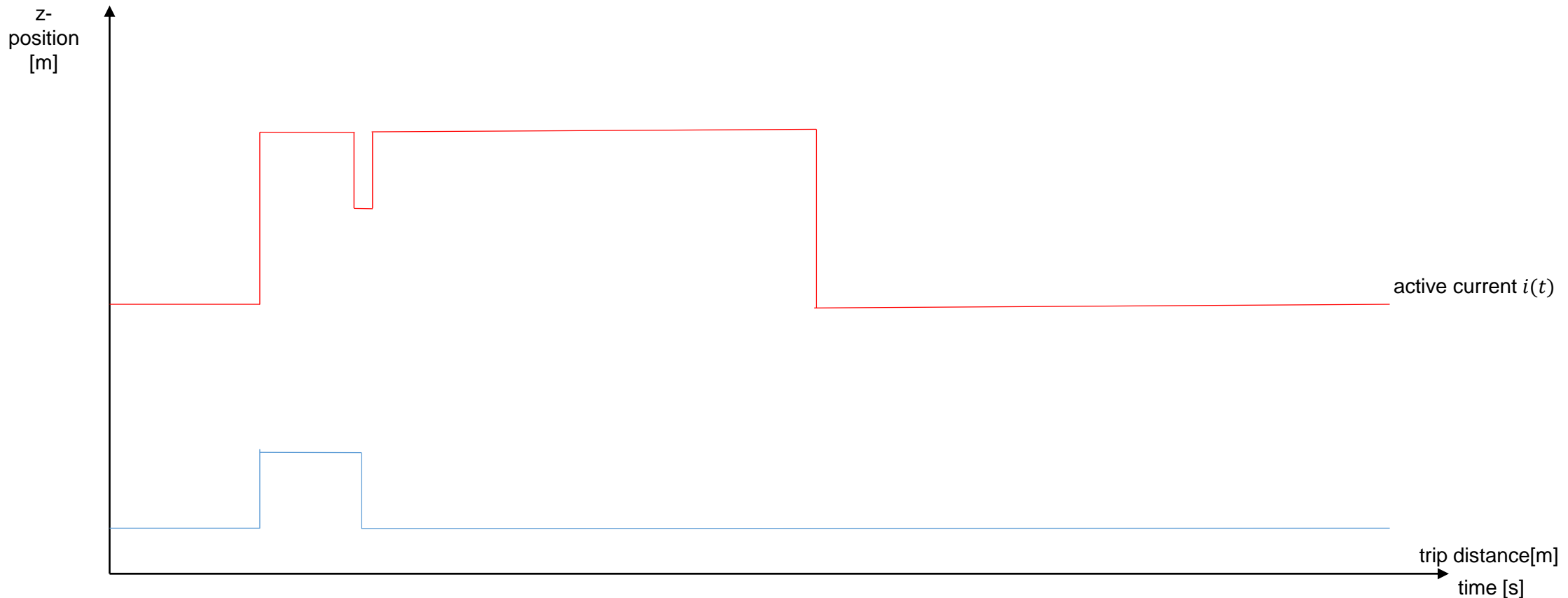
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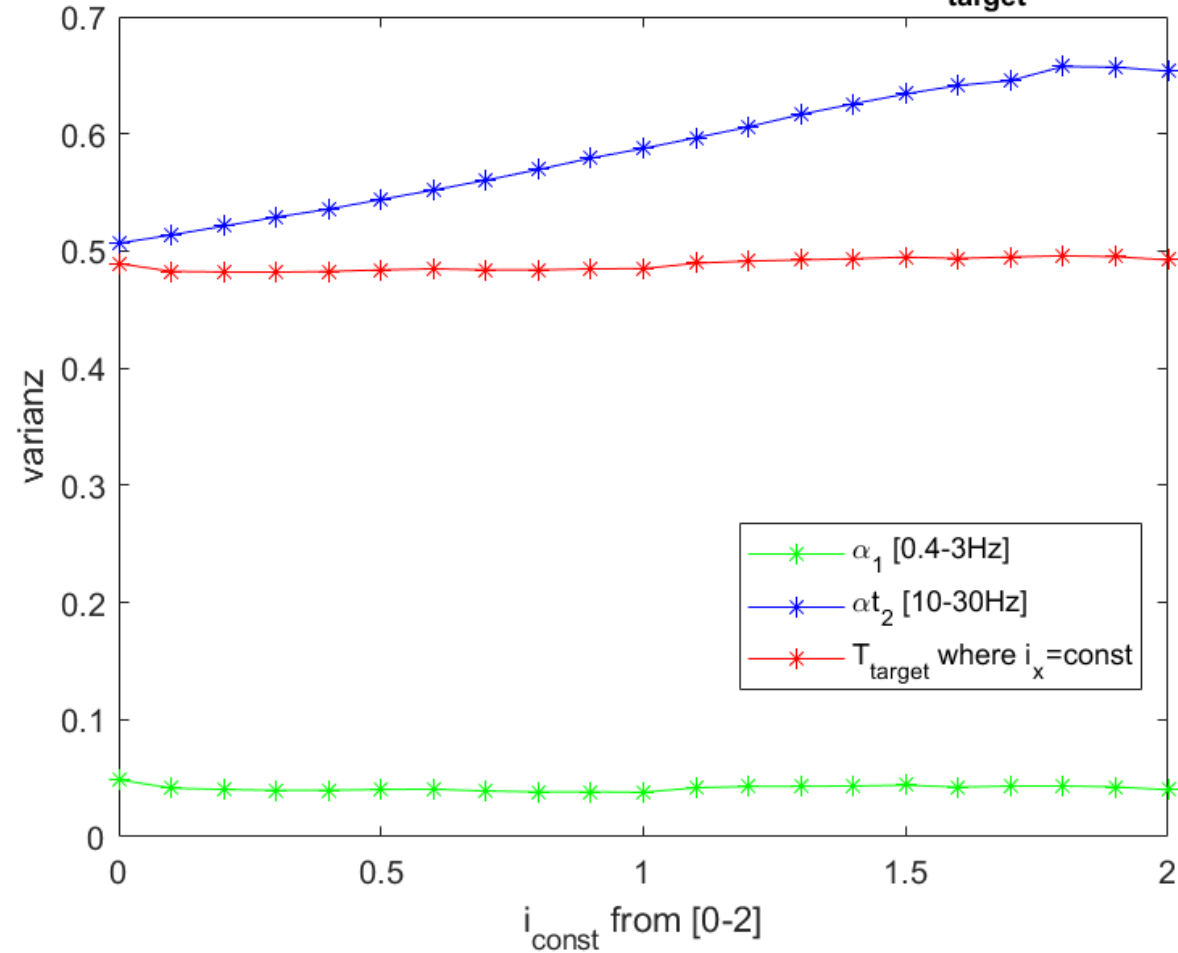
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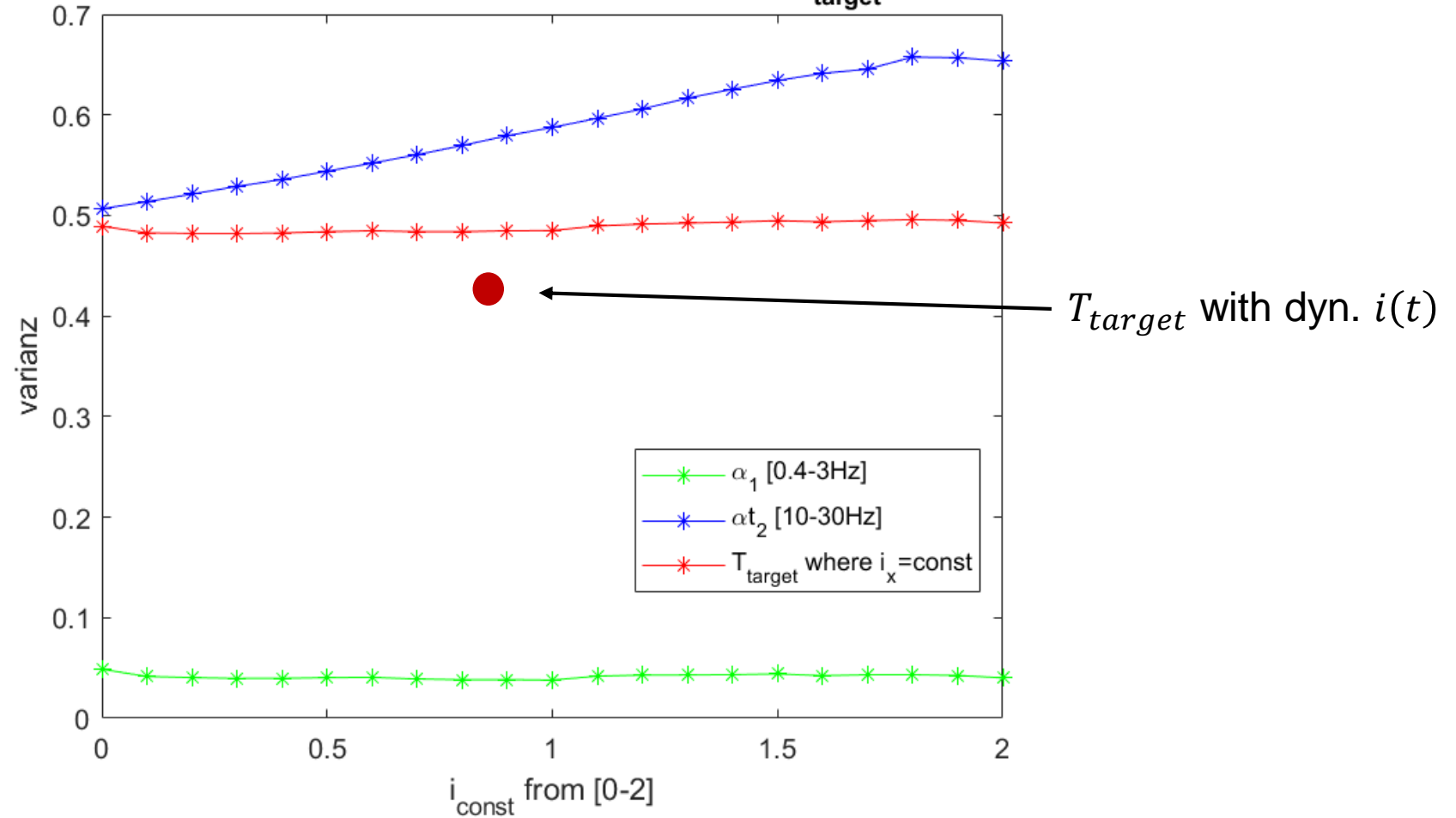
# Example Speed Bump – Simulation – $i_{const}$

Non dynamic damper activation on speed bump;  $v=20$ ;  $T_{target}$  shifted by +0.2



# Example Speed Bump – Simulation – $i_{const}$

Non dynamic damper activation on speed bump;  $v=20$ ;  $T_{target}$  shifted by +0.2

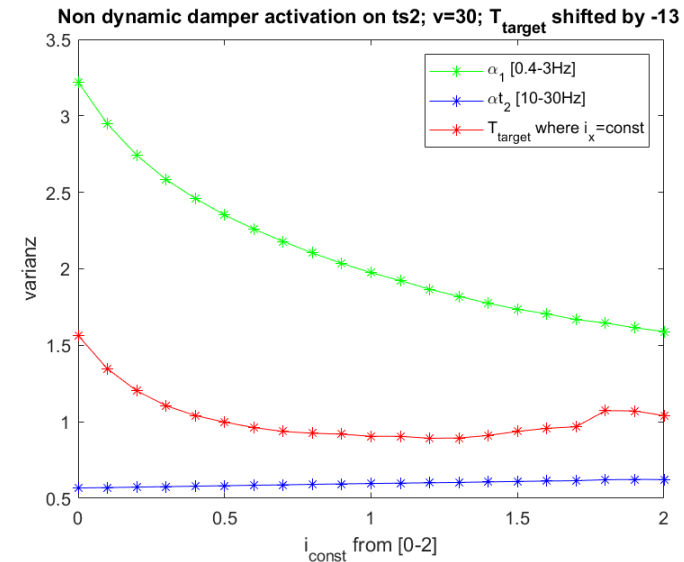
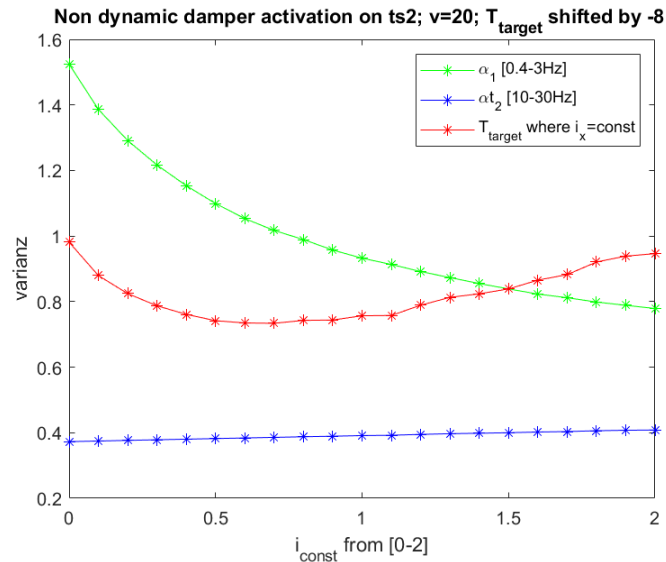
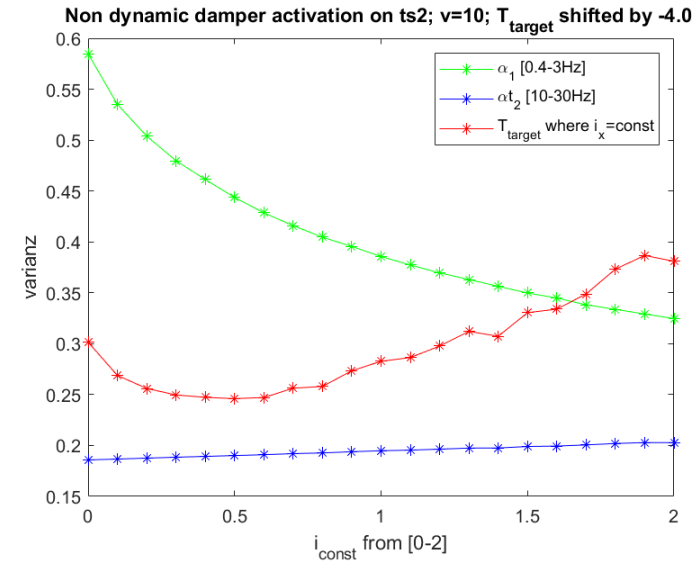
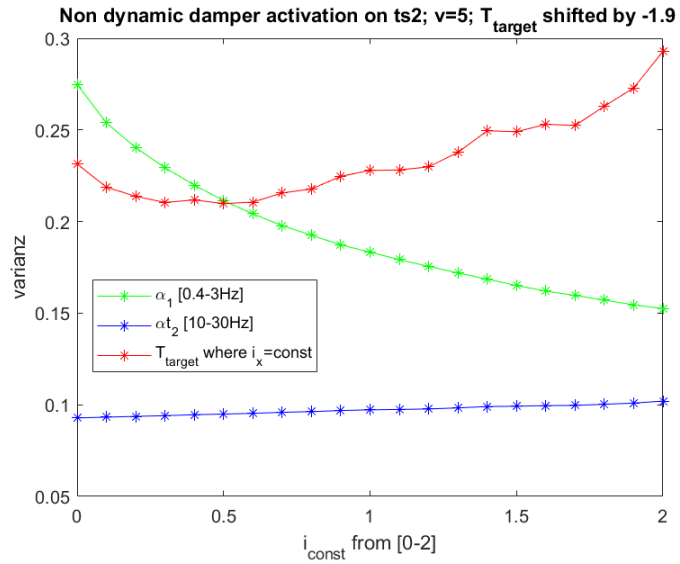


# Example Speed Bump

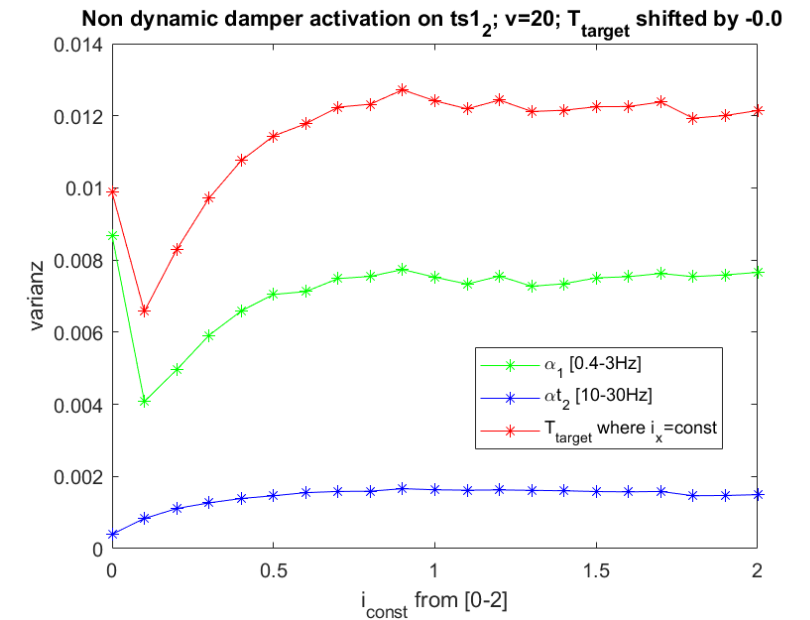
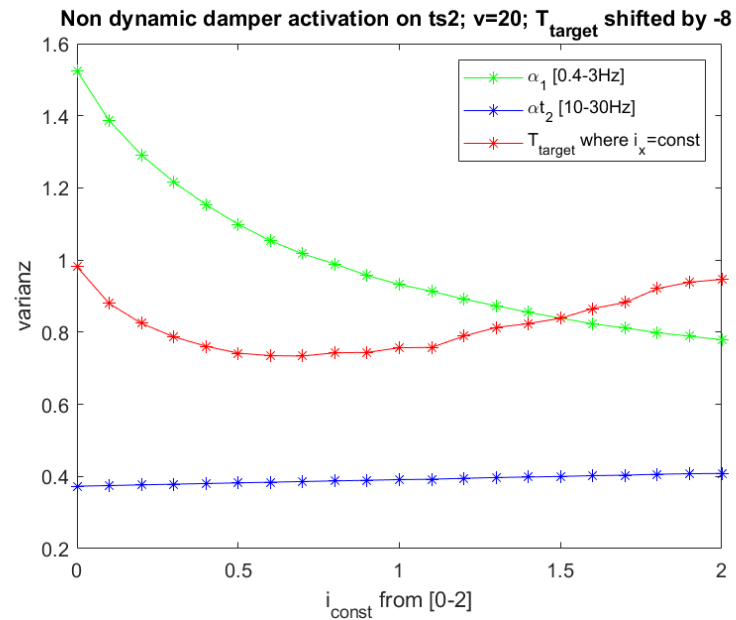
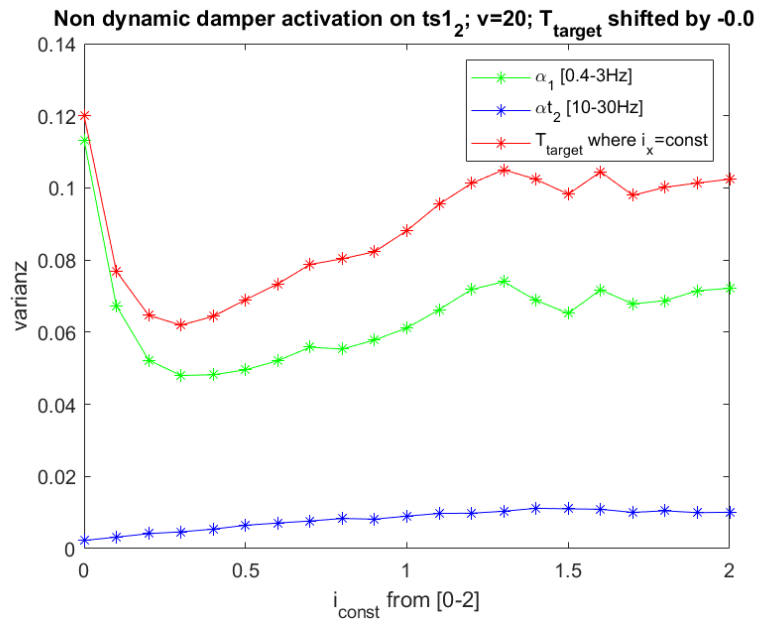
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- code of speed bump example can be found at
  - `/net/projects/scratch/winter/valid_until_31_July_2020/hackathon/codeSnippets/damperTask/runDamperOnSpeedBump.py`
- before first use e.g. install python virtual environment
  - `python3 -m venv ~/hack20`
  - `source ~/hack20/bin/activate`
  - `pip3 install scipy`
  - `pip3 install matplotlib==1.5.3`
  - `python3 runDamperProfile.py`
- copy the code snippets to a folder where you can read & write

# $T_{target}$ and $v = [5; 10; 20; 30]$ of ts2



# $T_{target}$ and $v$ of some data sets



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# Code Snippets

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# Schedule of the Weekend



# Schedule of the Weekend

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- 09:15 on Friday: starting event
- 16:00 on Saturday: hand-in half-time scoring results
- 18:00 on Saturday: release half-time scoring
- 17:00 on Sunday: release of data set ts4\_k\_?? .csv
- 19:30 on Sunday: hand-in of final results and code
  - Final hand-in must include
    - Scoring-CSV
    - Code for reproducing your results (incl. possible links to other data sets, tools etc.)  
**Commitment to open source:** all software based on the released task as well as dataset had to be licensed according to the MIT License.
- 20:00 on Sunday: End of the hack

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Half-time scoring  
Saturday 18:00

# Half-time scoring Saturday 18:00

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- Hand-In time: Saturday 16:00
- Julius will collect (with his USB)
  - “HalfTimeScoring\_ts\_3\_1\_vel20.0.csv” with  $v = 20 \frac{m}{s}$  and  $dt = 0.005s$
  - “HalfTimeScoring\_ts\_3\_1\_vel8.0.csv” with  $v = 8 \frac{m}{s}$  and  $dt = 0.005s$
  - “HalfTimeScoring\_ts\_3\_1\_vel27.0.csv” with  $v = 27 \frac{m}{s}$  and  $dt = 0.005s$
- Run your implementation on data set ts3\_2 \_k\_3.0.csv
- Scoring results will be without values, only the ranking
- Participation is voluntary but a good chance

# HalfTimeScoring\_ts\_3\_1\_vel??.csv

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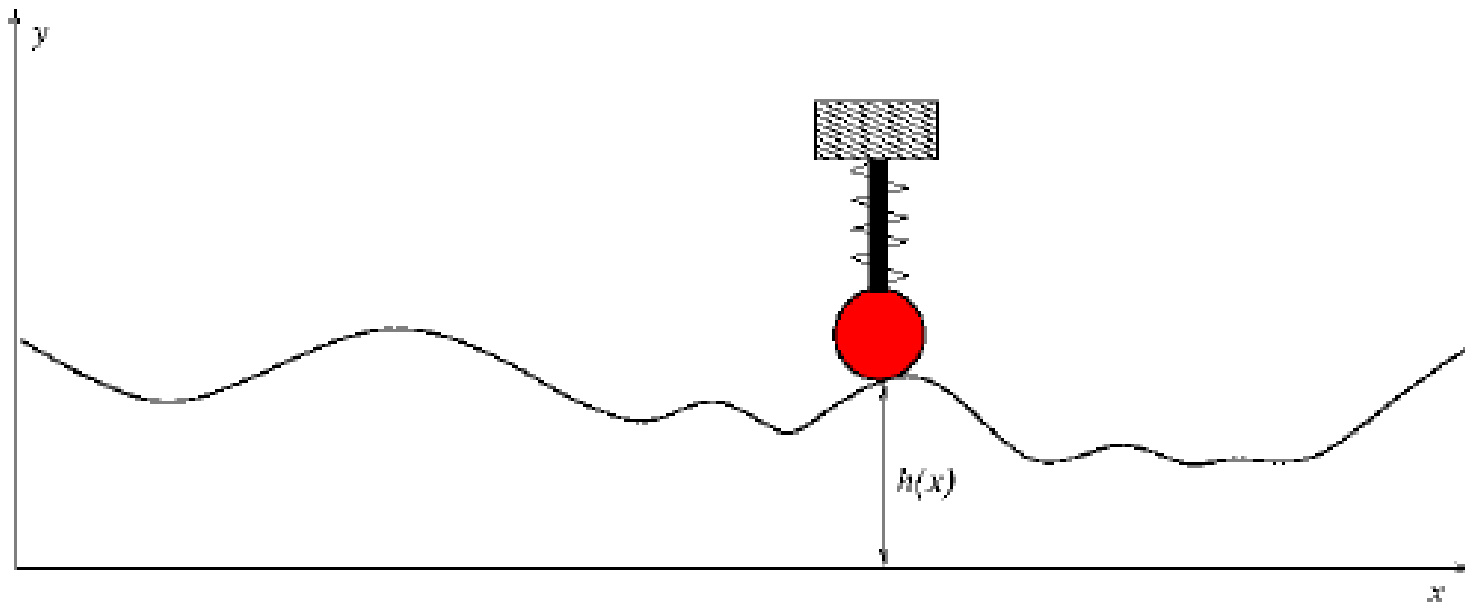
- must include  $[t, Z_h, Z_t, Z_b, \ddot{Z}_t, \ddot{Z}_b, i]$
- The length might variate by  $\pm 10$  rows @  $dt = 0.005s$ 
  - $v_{20} = 12\,338$  rows
  - $v_8 = 309\,592$  rows
  - $v_{27} = 91\,732$  rows

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# Some starting points

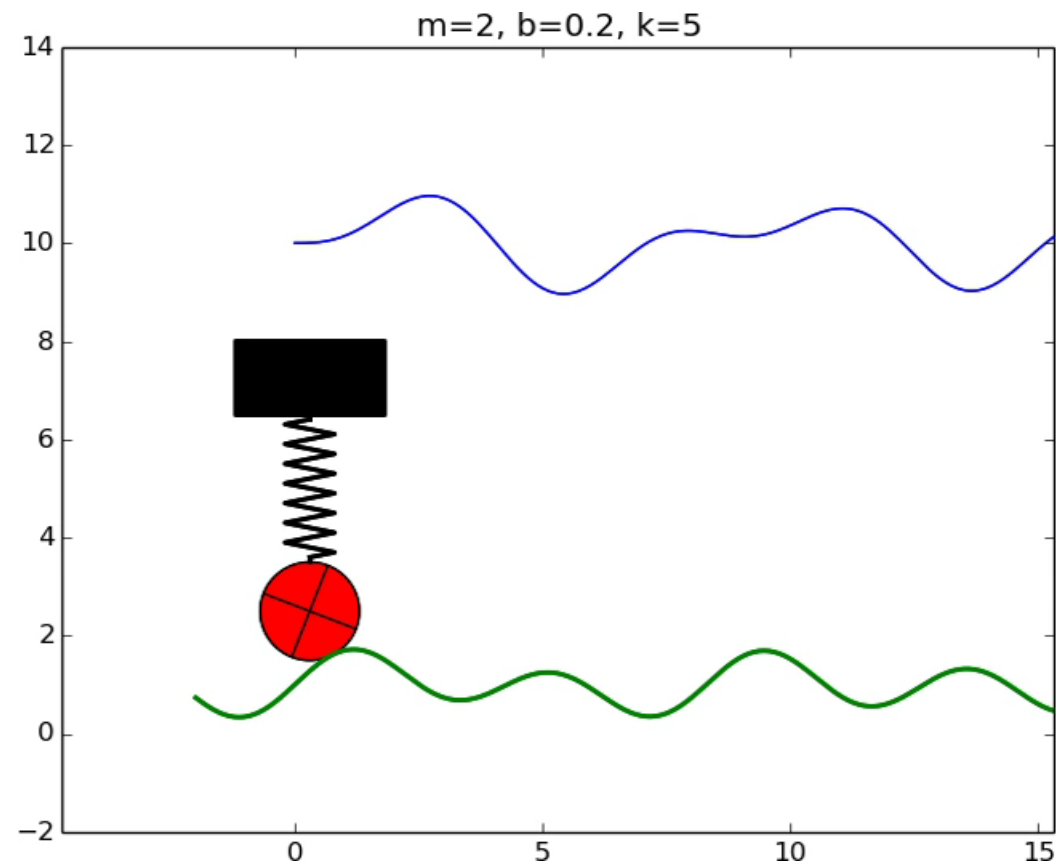
# Damper Spring System in Python

- A worked example on scientific computing with Python
  - cf. <https://github.com/hplgit/bumpy>
  - cf. /net/projects/scratch/winter/valid\_until\_31\_July\_2020/hackathon/codeSnippets/simpleDamperNotTheTask



# Damper Spring System in Python – Animation

- [https://raw.githubusercontent.com/hplgit/bumpy/master/doc/src/mov-bumpy/m2\\_k5\\_b0\\_2/movie.webm](https://raw.githubusercontent.com/hplgit/bumpy/master/doc/src/mov-bumpy/m2_k5_b0_2/movie.webm)



# A case study of car suspension system

- Solution approaches to differential equation of mechanical system dynamics: A case study of car suspension system
  - Tesfaye O. Terefe, Hirpa G. Lemu

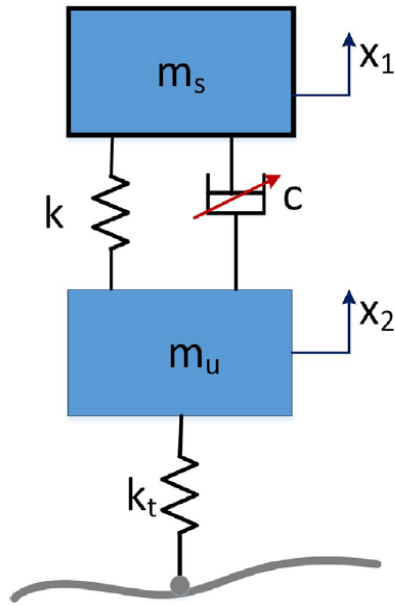


Fig. 2. Illustrative model of a semi-active suspension system

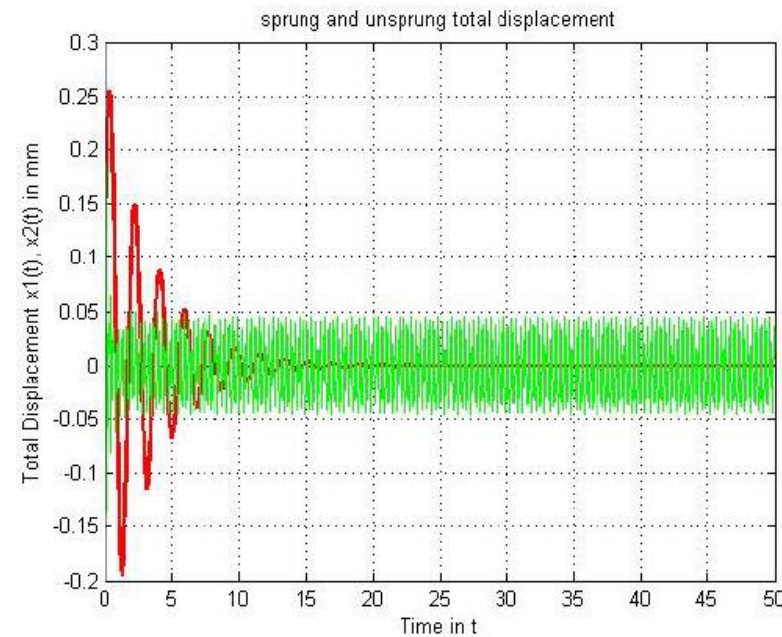


Fig. 9. Overall system response



# Further reads ...

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- <https://www.youtube.com/watch?v=gsk6kPaP2Ig> NumPyQuarter Model Suspension : Python
- <http://ctms.engin.umich.edu/CTMS/index.php?example=Suspension&section=SystemModeling> Suspension: System Modeling
- <https://www.youtube.com/watch?v=6ivdfKfGp4k> Simulating Feedback Control Systems
- <https://github.com/nrsyed/half-car> Vehicle half-car suspension model
- <http://apmonitor.com/pdc/index.php/Main/SpeedControl> Automobile Velocity Control
- <https://github.com/python-control/python-control/blob/master/examples/steering-gainsched.py> gain scheduled control for vehicle steering
- [https://physics.nyu.edu/pine/pymanual/html/chap9/chap9\\_scipy.html](https://physics.nyu.edu/pine/pymanual/html/chap9/chap9_scipy.html) Numerical Routines: SciPy and
- <https://apmonitor.com/pdc/index.php/Main/SolveDifferentialEquations> ODEINT Solver
- ...

# Other organizational matters

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- Announcements -> to all people via e-mail

# In case of emergency

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- In case of medical emergency and fire
  - First: Call 112
  - (continue with first aid or fire fighting)
  - Later call 0541 969-7150 (Julius) or call 0541 969-2277 (Gordon)
- In case of contacting hackathon-team
  - First: try to find Julius, Gordon, Pascal, Ulf, ZF experts, etc.
  - if still necessary and in urgent cases call 0541 969-7150

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# Result Presentations and Awarding Ceremony

22.01.2020 14:00 (ct) room SI 0036

# Judging criteria

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- technical evaluation of your solution 50%
- 10-minute presentation of your solution 40%
- creativity, novelty, applicability of your solution 10%

# Jury – changes still possible

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- The jury will be six persons
  - ZF: Dr. M. Klank
  - ZF: Dr. T. Pobandt / Dr. Ch. Elbers
  - Uni Osnabrück: Prof. Dr. G. Pipa
  - Uni Osnabrück: P. Nieters
  - Hochschule Osnabrück: Prof. Dr. Th. Gervens
  - Hochschule Osnabrück: Prof. Dr. C. Westerkamp

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# Room assignment

# Rooms available

Rooms	Remark	
E07	Fr. 14:00-16:00 (blocked)	
E08		
E04	Fr. 10:00-12:00 (blocked)	
E03		
E02		
113		
111		
119		
228		
220		
219	Snack-Bar (Coffee, Tea, cake, etc.)	
E09	Fr. until 14:00 (blocked)	
...		