MEC-E5001 Mechatronic Machine Design Project Work

Crane Hook Sway Simulation and Control

Group R: Waqas Ahmad– Adel Ansari

Instructor: Professor Kari Tammi

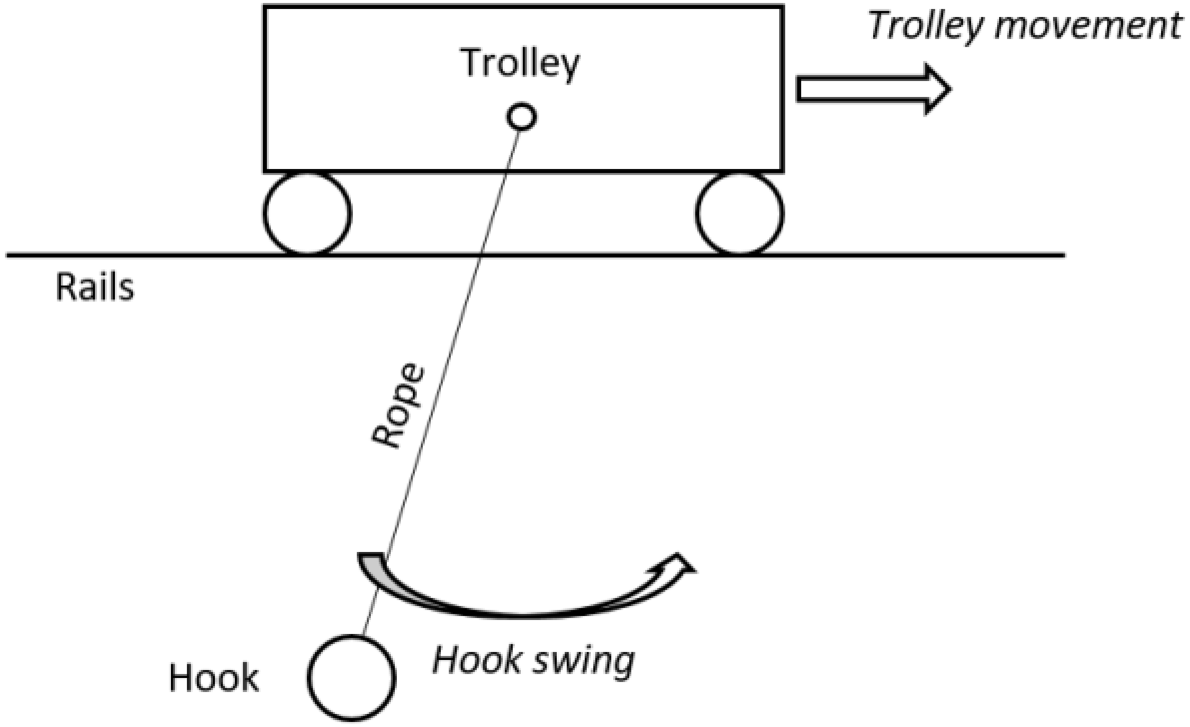
Department of Mechanical Engineering, Aalto University

Aalto University
School of Engineering

Presentation Overview

Aalto University
School of Engineering

1. Introduction and Numeric Modelling
2. CAD Modelling
3. Components
4. Simulation model and control
5. Closure

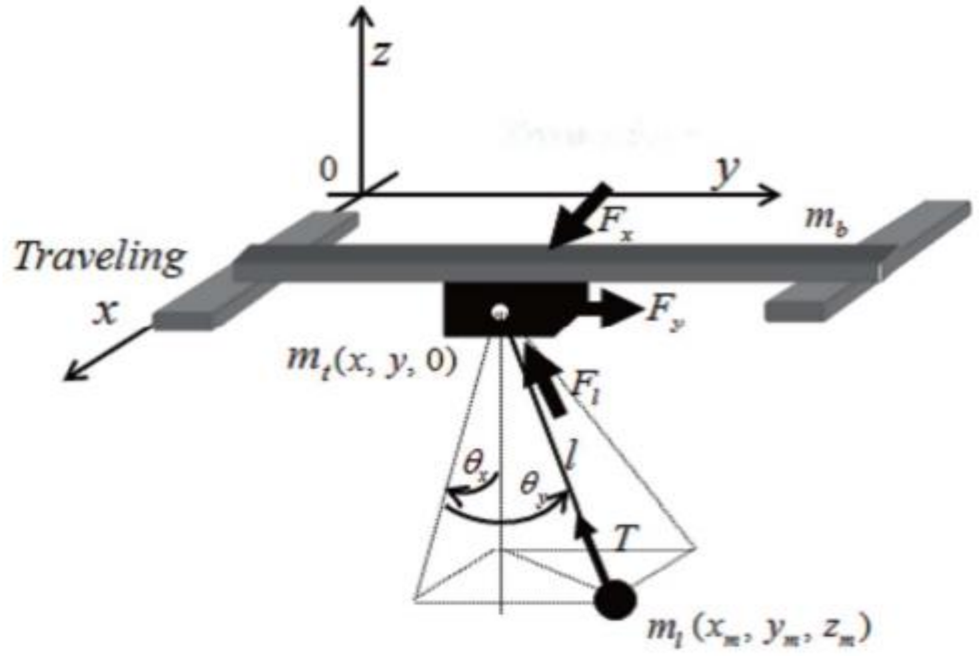


1. Introduction and Numeric Modelling

The non-linear dynamic model of crane is derived using Lagrange equations as follow:

$$(m_t + m_l)\ddot{y} + m_l l\left(\ddot{\theta}_y cos\theta_y - \dot{\theta}_y^2 sin\theta_y\right) = F_y$$

$$cos\theta_y \ddot{y} + l\ddot{\theta}_y + gsin\theta_y = 0$$



By assuming small motion of θ_y and $\theta = 0$ as the stable equilibrium of the system, the following linearized model of the crane is obtained:

$$(m_t + m_l)\ddot{y} + m_l l\ddot{\theta}_y = F_y$$

$$\ddot{y} + l\ddot{\theta}_y + g\theta_y = 0$$

Reference: http://pep.ijieee.org.in/journal_pdf/11-203-145266708028-33.pdf

1. Introduction and Numeric Modelling

Aalto University
School of Engineering

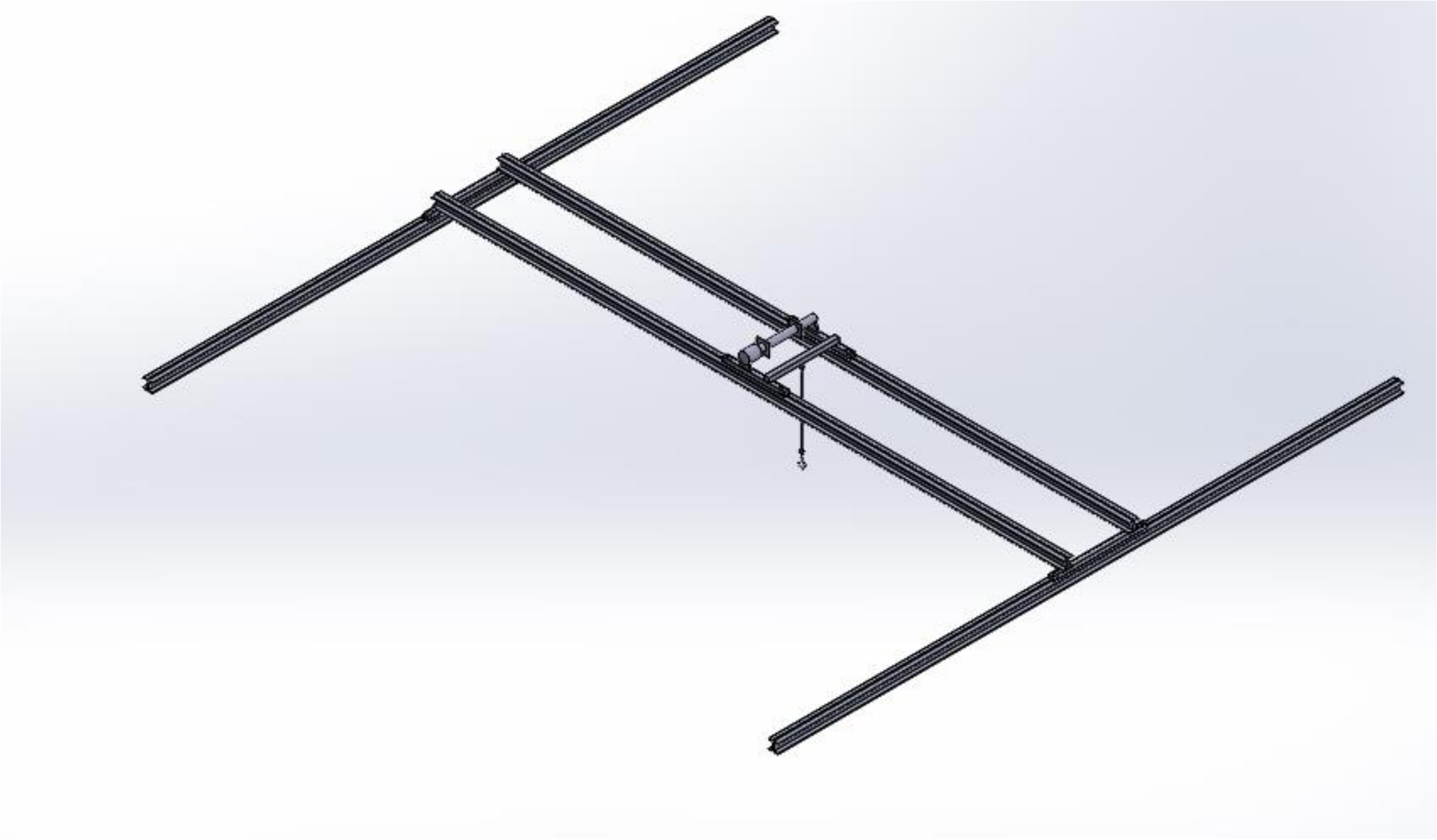
The state space model of the crane can be obtained as:

$$\dot{X} = Ax + Bu$$

$$Y = Cx + Du$$

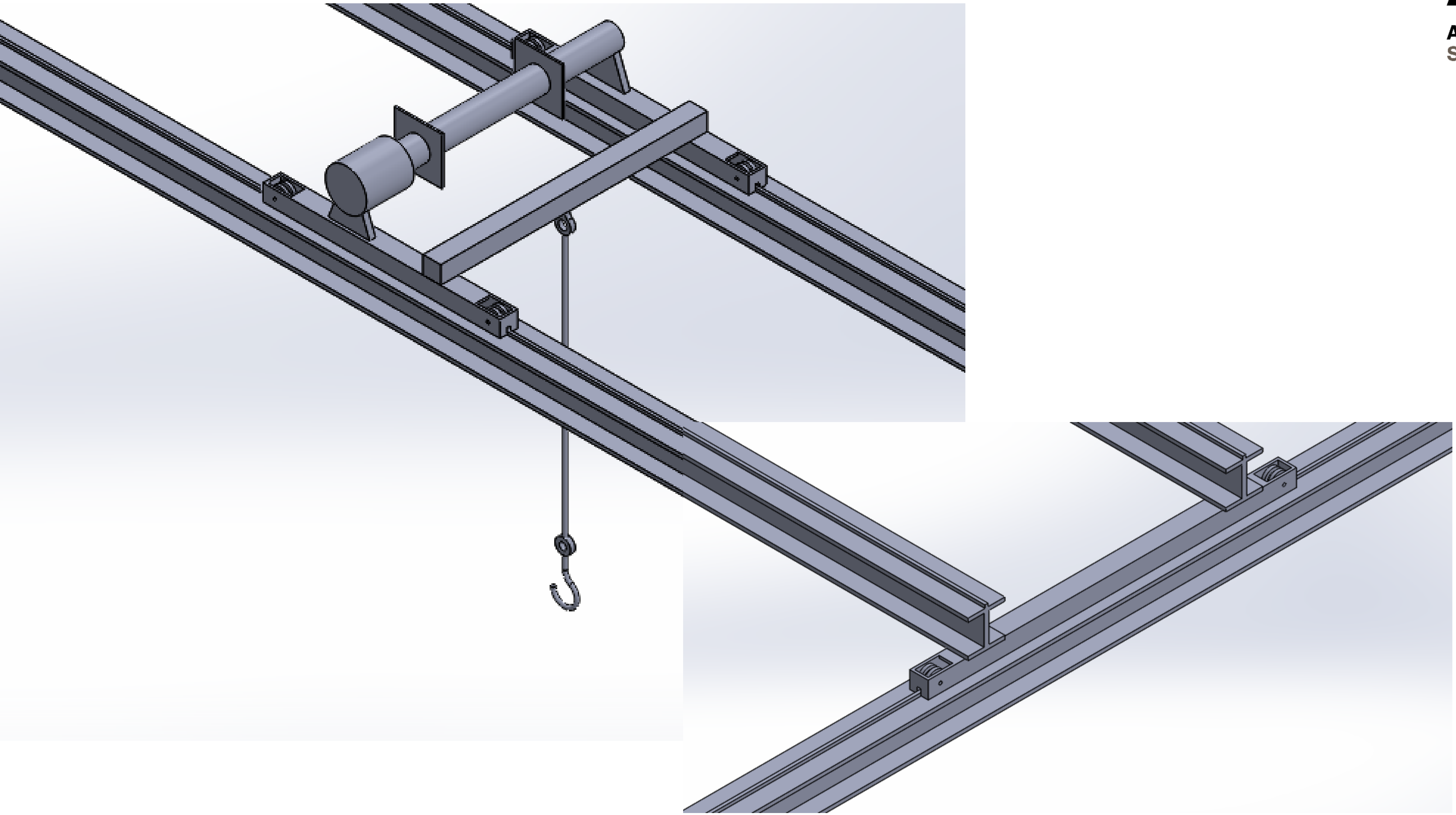
$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & \dfrac{m_l g}{m_t} & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & -\dfrac{(m_t + m_l)g}{m_t l} & 0 \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 1/m_t \\ 0 \\ -1/m_t l \end{bmatrix} \qquad C = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \qquad D = [0]$$

2. CAD Modelling



Aalto University
School of Engineering

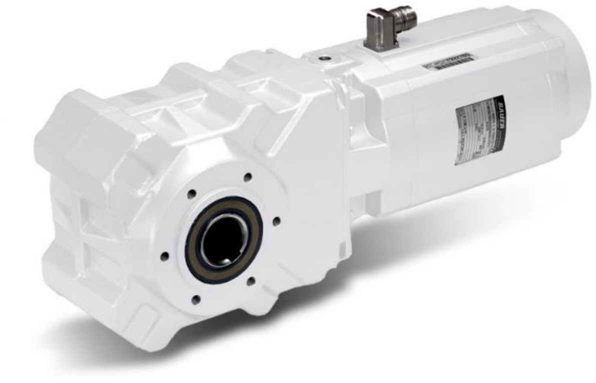
2. CAD Modelling



3. Components

AsepticDRIVE | Bauer Gear Motor

Power rating 0,37 -2,2 kW



The angle of the “rope” will be measured by using a **SeeedStudio Grove Rotary Angle Sensor** and **analog potentiometer**.

PLC Controller (CLESCRANE)

Amerigear® Class I Gear | Ameridrives

CRANE® 44000 Electric Actuators

4. Simulation model and control

Aalto University
School of Engineering

```
l=0.5 %:0.5:3.0 % rope length
v=20             % Trolly max speed [m/min]
L_2=9            % Trolly movement range [meters]
m_t=250          % Trolly weigth [kg]
m_max=3200       % Lifting capacity
m_hook=5         % hook wight
m_l=m_max+m_hook;
g=9.81;
s=tf('s')
P_t=(l*s^2+g)/((m_t+m_l)*l*s^4+(m_t*g+m_l*g-m_l*l))
P_p=s^2/(m_l*l*s^4-(m_t+m_l)*l*s^2-(m_t*g+m_l*g))
```

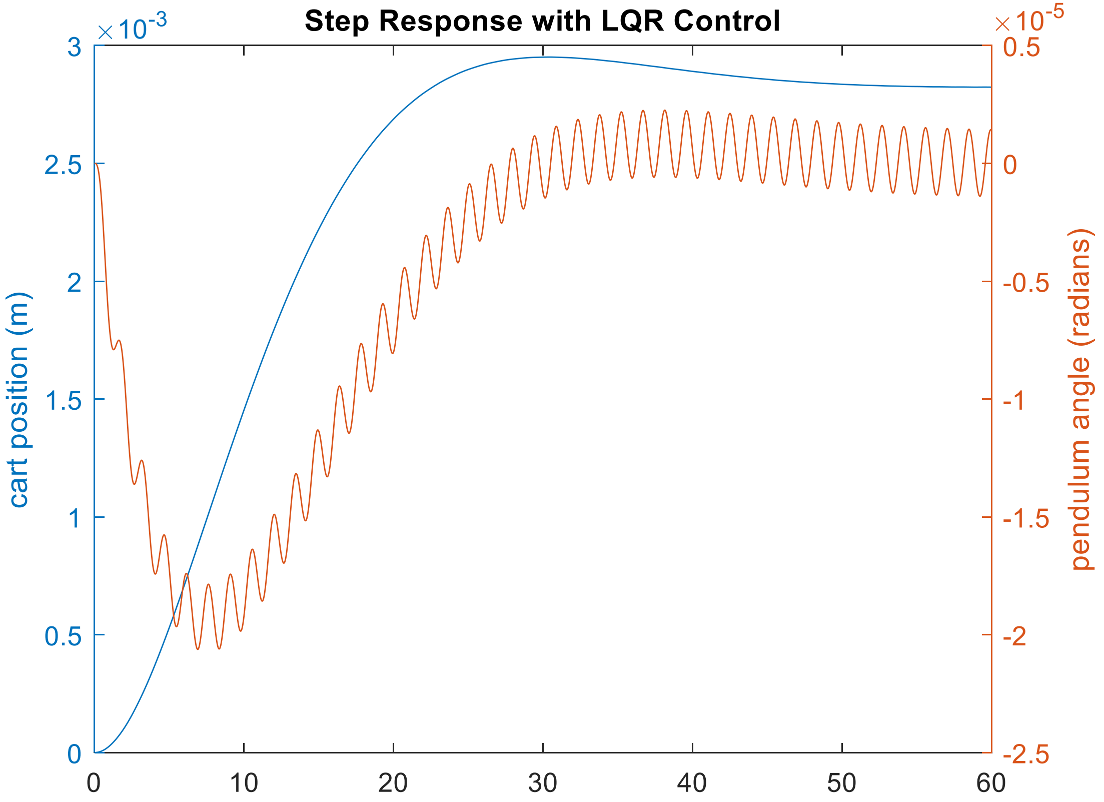
```
P_t =

    0.5 s^2 + 9.81
  --------------------
  1728 s^4 + 3.229e04

Continuous-time transfer function.


P_p =

              s^2
  ------------------------------
  1603 s^4 - 1728 s^2 - 3.389e04

Continuous-time transfer function.
```

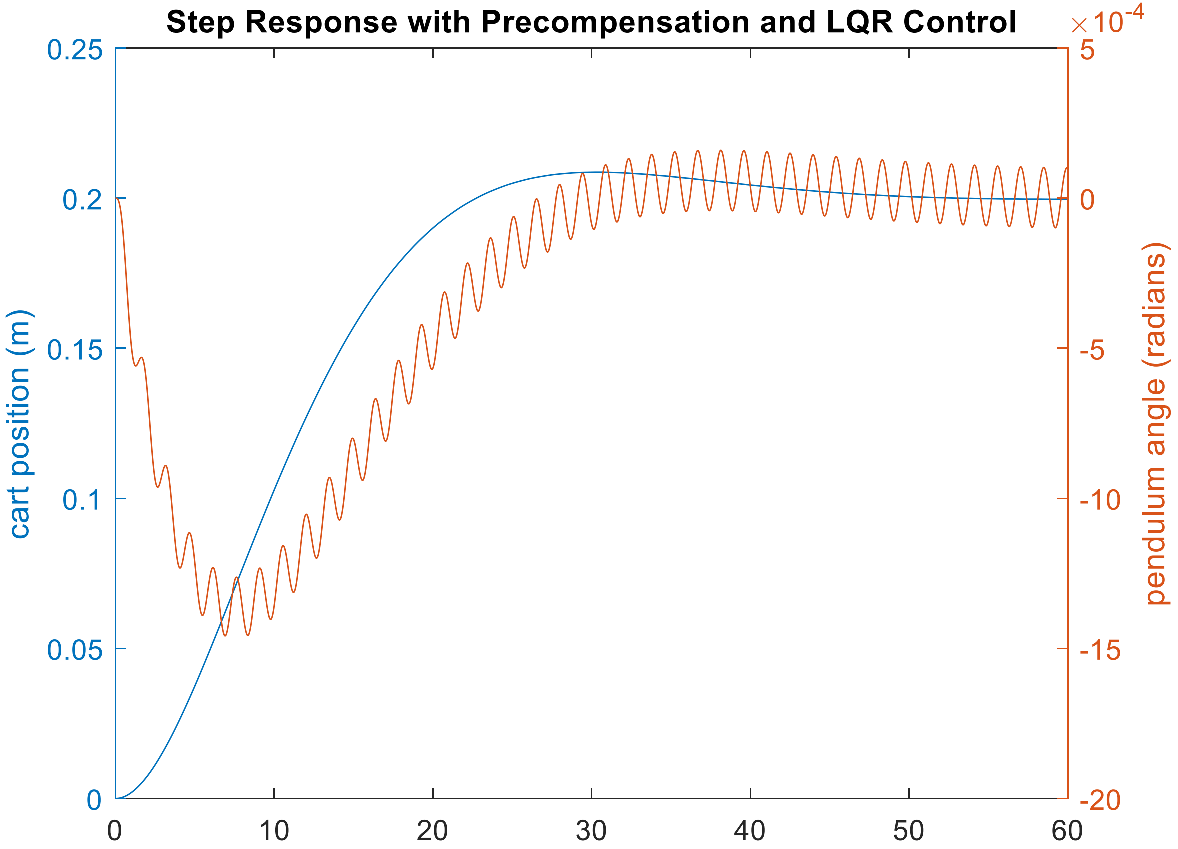
```
sys_tf =

  From input "u" to output...
           0.5 s^2 + 9.81
   x:  --------------------
       1728 s^4 + 3.229e04

                    s^2
   phi:  ------------------------------
         1603 s^4 - 1728 s^2 - 3.389e04

Continuous-time transfer function.


controllability =

     4
```

```
K =

   70.7107  717.5049  345.3303   -1.8960


Nbar =

   70.7107


observability =

     4


poles =

  -0.1036 + 0.1036i
  -0.1036 - 0.1036i
  -0.0002 + 4.3235i
  -0.0002 - 4.3235i
```

4. Simulation model and control

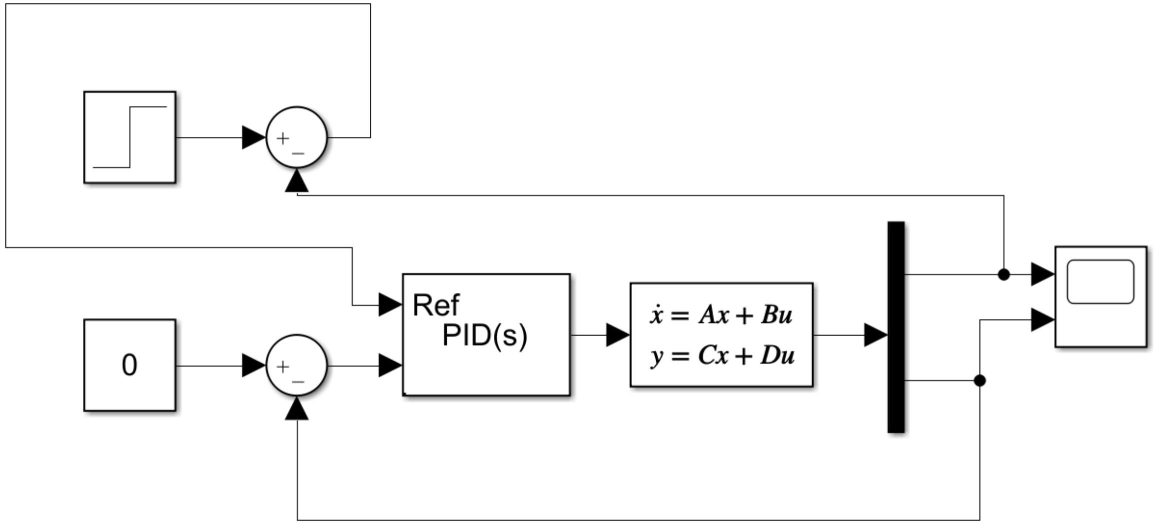
Aalto University
School of Engineering

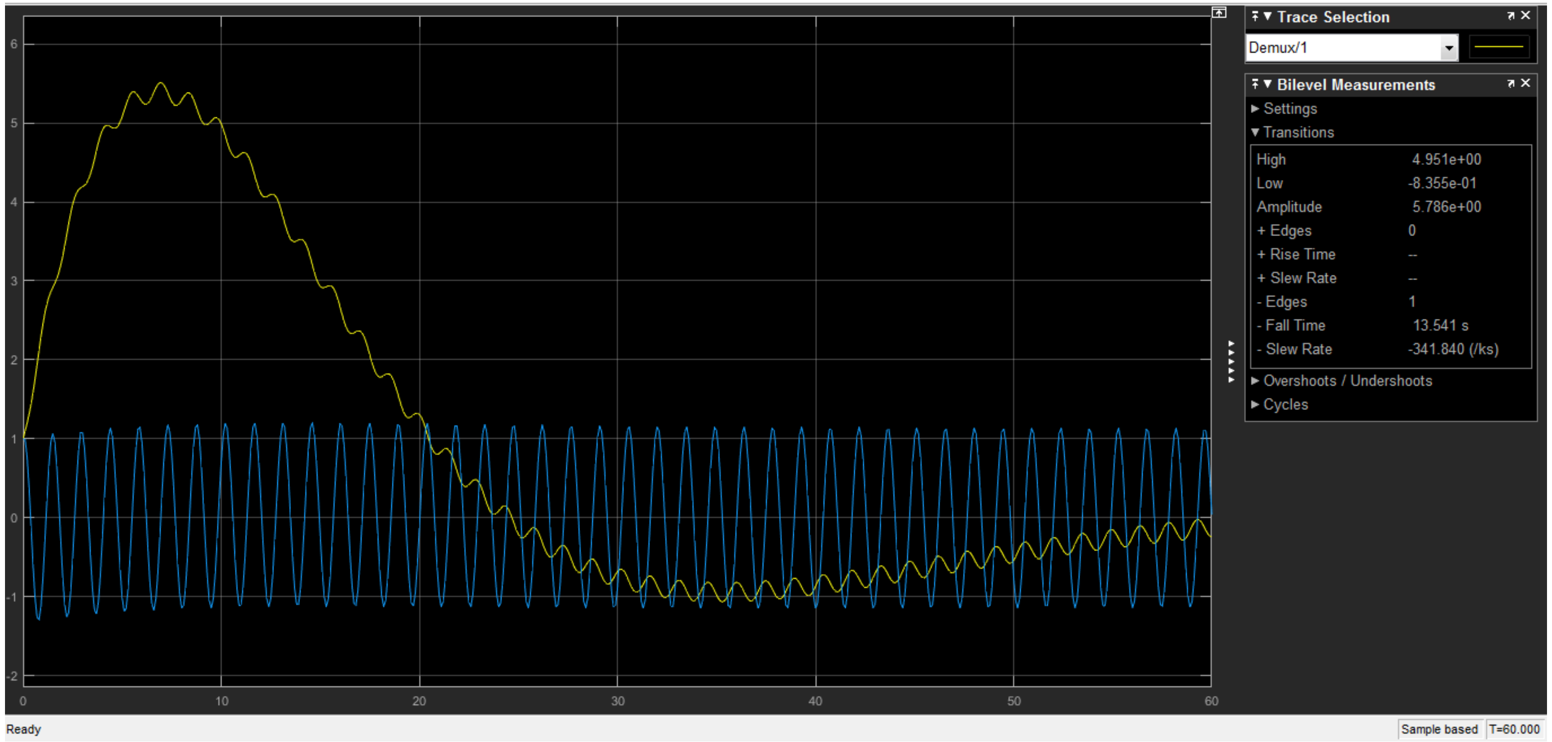




4. Simulation model and control

Aalto University
School of Engineering





5. Closure

Aalto University
School of Engineering