**MECT 613 – MICROCONTROLLERS – FALL 2017**

**MIDTERM PROJECT**

SELF-BALANCING ROBOT

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| **PREPARED BY** | |
| Mohd Saiful Akmal Bin Razali | 171021 |
| Gabriel de Brito Silva | 171020 |
| Hedaya Ali | 171103 |
| Berit Adina Haendel | 171018 |

**Prepared for:**

Prof. Mahmoud El-Samanty

**SCHOOL OF ENGINEERING & APPLIED SCIENCES (EAS)**

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# 0 Introduction

# 1 Hardware

# 2 Theoretical analysation

## 2.1 Inverted pendulum

The self-balancing robot can be described as an inverted pendulum. As a simplification we assume that the robot is mainly unstable in rotation around the wheel axis. Therefore, the model becomes 2-diminsional (z- and x-axis) and 2-DOF (position on x-axis and inclination angle).

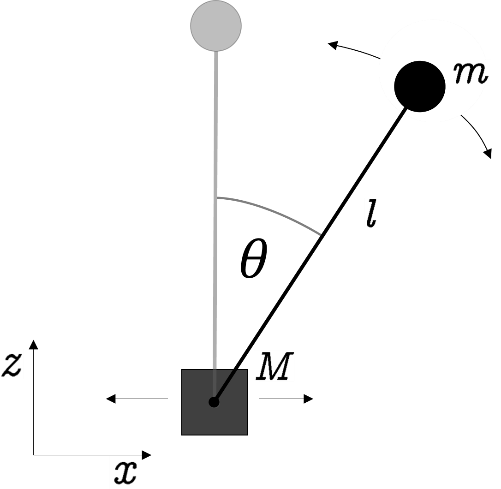
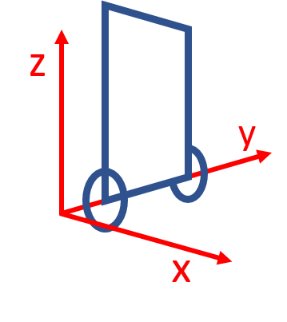


Fig. 1 Coordinate system for self-balancing robot. Relates to a fixed point on the ground. Assuming that robot will not rotate around z-axsis.

The pendulum consists of a mass point *m* at () which is connected to the base’s mass point *M* at (). The pendulum can freely rotate around the joint point and *M* can be move along the *x*-axis. To obtain the equations of motion for the system, we first determine the Lagrange equation consisting of the cinematic energy *T* and the potential energy *V* of the system:

With the inertia moment of the mass *m* rotating around point *M*. Since the coordinates are given through

, , ,

we can derivate them

, , ,

and insert the results into the Lagrange equation:

Now, the relevant equation of motion for the system can be obtained by applying the following Euler-Lagrange equation.

## 2.2 Calculation of angle

# 3 Design

## 3.1 Frist design approach

## 3.3 Reworked: Second design approach

# 4 Code

# 5 Others

## 5.1 Descriptions of attachments

## 5.2 Used references

<http://www.kerrywong.com/2012/03/08/a-self-balancing-robot-i/>

Ogata, 2010, Modern Control Engineering, Fifth Edition, p.69 ff.