Lab Report – Claudio + Freddie

## Introduction

Over the course of the past week, we have developed a control system for a MIMO analysis of the Lego Mindstorm EV3 robot. To achieve stability and some performance requirements, we have independently designed a SISO closed-loop system for each variable  
(namely x1 = [θ; ψ; θ˙; ψ˙] and x2 = [φ; φ˙], where these angles represent:

* θ = common mode rotational angle of left and right wheel
* ψ = pitch angle of the body with respect to the vertical
* φ = yaw angle

We obtained a linearised approximation of the system’s dynamics and applied two different approaches in order to determine our controller gains. The first involved the use of a root locus plot and the second direct pole placement. We then tested our control system on the hardware, implementing a gamepad to control the robot’s movement.

## Mathematical Model

We started our analysis by deriving a mathematical representation of the system’s state space. Due to the presence of several non-linear terms, we linearised the dynamics about a pitch angle ψ of 0 degrees (vertically upwards), yaw and common mode angles φ and θ of 0, pitch, yaw and common mode velocities ψ˙, φ˙, θ˙ of 0. Physically, this meant our model’s validity relied on the assumption that the robot would stand upright during operation. This placed some limitations on the range of attitudes our robot could achieve whilst being stable.

Our working out for questions 1-12 is attached below.