Session index (50min each)	Title	Intended Learning Outcomes	Teaching Material and Learning Activities
1	Project introduction	• overview of the purpose of the project • overview of what one is expected to do and learn • overview of what is going to happen and the timeline • expliciting why what is being taught by this course has societal relevance	• slides • demonstration with the robot
2	Introduction about feedback, control and modelling	• understanding through examples of what control, feedback and modelling mean • expliciting their usefulness in this project	• slides • examples from the paper from Daniel Abramovitch at Agilent
3	Building the robot	• building the robot by following the instructions	• instruction manual
4	Testing the robot and learning its hardware components	• connecting the robot to the development interface • doing simple tests to check that everything works • learning what is what and why these parts are useful	• instruction manual • informal assessment
5	Mathematical model of robot dynamics, part 1	• understanding what a dynamical model is and what is its purpose • recalling which mathematics will be used to model our robot (thus recalling trigonometry and basic physics)	• slides • instruction manual
6	Mathematical model of robot dynamics, part 2	• inspecting the model to get physical intuitions • discussion around its properties and usefulness	• slides • exercises
7	Control systems examples	• analyzing the use-cases and associated challenges in the reality around us • examples about artificial pancreas, rockets, and telecommunications	• slides • examples from the paper from Daniel Abramovitch at Agilent
8	What it means to control a segway robot	• understanding what equilibria are • understanding what it means to control an inverted pendulum	• slides • exercises
9	Loading the code and the libraries on a computer	• performing the basic operations that are needed to implement a controller • inspecting the various parts of the code and what they do, their usefulness and purpose	• slides • exercises • instruction manual
10	Testing and debugging the sensors	• testing the system • collecting data from the sensors, and understand what they mean • checking if there are problems with the hardware • tuning the sensors • understanding why the sensors are a bottleneck in every control system	• exercises • instruction manual • demonstration with the robot
11	Introduction to PID controllers	• getting intuitions of what is a PID is through getting what are the physical meanings of the various parts • getting intuitions about what are the effects of changing the weights on the closed loop • getting intuitions about how to tune a PID	• slides • exercises • instruction manual
12	PID control of the simulated robot, part 1	• testing a PID using the simulator • inspecting the code in the simulator • understanding how the code of the simulator corresponds to the code in the hardware platform	• exercises • instruction manual • simulator
13	PID control of the simulated robot, part 2	• fiddling with the parameters of the PID • learning how to do tuning by experimenting on the virtual platform	• exercises • instruction manual • simulator
14	Balancing robots tournament - race 0	• competing one against the other so to push to find the fastest configuration possible in simulation • discussing the results all together	• instruction manual • demonstration with the robot
15	Implementation of the PID code in the hardware platform	• writing the code in the hardware • testing that there are no bugs	• instruction manual • demonstration with the robot
16	Testing and tuning the PID controller in the real world	• finding a configuration that makes the robot balance • finding a configuration that makes the robot the fastest possible without falling	• instruction manual • demonstration with the robot

17	Balancing robots tournament - race 1	• competing one against the other so to push to find the fastest configuration possible • discussing the results all together	• demonstration with the robot
18	Towards trajectory tracking: extending the mathematical model of the robot	• completing the mathematical model of the robot so to include also the possibility of rotating	• slides • exercises • simulator
19	Trajectory tracking using the simulator, part 1 (understanding)	• understanding how to make the robot rotate using differential driving • planning which controller (P, PI, PID) one may use to control this rotation	• slides • simulator
20	Trajectory tracking using the simulator, part 2 (coding and testing)	• implementing the rotation controller in the simulator, and testing the strategy • verifying that there may be some stability issue if one is too aggressive in the rotation part	• slides • simulator
21	Trajectory tracking in the real life: the need for feedforward control	• verifying, using the platform, that the sensors may not give reliable information • introducing the concept of feedforward	• slides • exercises • simulator
22	Trajectory tracking using the simulator, part 3 (feedback vs feedforward)	• implementing and comparing feedforward against feedback in the simulator • understanding the usefulness of the different parts	• slides • exercises • simulator
23	Implementation of the feedforward component in the hardware platform	• translating the results obtained in the previous modules into the real platform, and testing them	• slides • instruction material • demonstration with the robot
24	Testing and optimizing	• trying different strategies and tuning • finding the best possible combination to follow a given specific trajectory	• slides • demonstration with the robot
25	Balancing robots tournament - race 2	• competing one against the other so to push to find the fastest configuration possible • discussing the results all together	• demonstration with the robot
26	How to write scientific documents	• inspecting and understanding the structure of scientific documents • getting intuitions about how each session should be written and why	• slides
27	How to create presentations	• learning effective presentation techniques, and the associated lists of "dos" and "dont's"	• slides
28	Preparation of the material that shall be presented	• preparing the material that shall be presented to the other peers	
29	Presentation of results	• 3 minutes presentations in front of the public	
30	Evaluation and reflections	• discussing what has been learned, what has been liked, what has been useful, what has not been positive	