

# TTK4190 Guidance and Control of Vehicles

## Problems

Created Fall 2016 and updated in 2018

### Objective

This is a set of problems that is meant to help you learn the curriculum. The problems are mainly concerned with the aircraft part of the curriculum, but some topics are common for both books. Many of the problems are related to definitions you should be familiar with before the midway exam. Obviously, these problems are not necessarily reflecting the type of questions on the midway exam directly, but cover some important topics. Moreover, you should know the definitions covered in these problems. We would, therefore, recommend you to take a look at these problems.

A draft solution for the problems will be posted with these problems. However, read the solutions critically because we cannot guarantee that everything is correct.

### 1 Introduction

- a) What is the simulation model?
- b) Why is the simulation model usually simplified when designing control laws?

### 2 Coordinate Frames

- a) Why do we need to look at both the body and NED frame?
- b) Why cannot NED be assumed inertial in global navigation?
- c) What is the gimbal lock?
- d) Define the angle of attack, flight-path angle and crab angle.
- e) What is the difference between course and crab?

### 3 Forces and Moments

- a) What kind of control surfaces are usually available in a fixed-wing UAV?
- b) What are the lateral and longitudinal states and why is it useful to decouple motion?
- c) What is stall?
- d) Why are the linear models for the drag and lift coefficients only valid for small angles of attack?
- e) What is static and dynamic stability for an aircraft?

### 4 Linear Design Models

- a) What is trim?

- b) Why are we often looking at linearized and simplified versions of the nonlinear equations of motion in control system design?
- c) What are the lateral states assumed to be when we are considering longitudinal motion?
- d) How can we find the short-period and phugoid mode?

## 5 Autopilot Design Using Successive Loop Closure

- a) Explain successive loop closure with your own words.
- b) What are the different zones in longitudinal autopilot design?
- c) What can happen with the bandwidth of a system when adding integrators to the inner loops?

## 6 Sensors

- a) Describe the sensors that usually are a part of fixed-wing UAV navigation systems. Write down what each sensor is measuring.
- b) Mention two types of estimators that can be used for state estimation. What are the advantages and disadvantages with each method?
- c) Describe one basic principle behind accelerometers. How can the accelerometer measurement be modeled in the Kalman filter?
- d) What is a pitot-tube measuring?
- e) Can you mention the main motivation behind replacing magnetic measurements with vision-based sensors for small UAVs?