1 INTRODUCTION

The material in these lecture notes is used in a junior- and senior-level course at MIT's Department of Mechanical Engineering, entitled *Design of Electromechanical Robotic Systems*. The key ingredient in this course - and what differentiates it from many other related courses - is the uncertainty that is encountered whenever a built system is actually installed in the field. We may find uncertainty in the operating environment, whether it is a windy airspace, a bumpy road, or an obstacle-strewn factory floor. We also find uncertainty in the parameters that define a system, for example, masses and stiffnesses and dampings, torque constants, and physical size. Finally, since complex electromechanical systems involve sensors and actuators, we have to acknowledge uncertainty in measurement and feedback control. Ultimately, such systems are meant to accomplish specific objectives, and the designer's task is to achieve robustness, performance, and cost-effectiveness in the presence of uncertainty.

The notes given here are terse but intended to be self-contained. The goal is to provide fundamental relations useful for modeling and creating systems that have to operate with uncertainty. As a motivation, we focus a lot of attention on ocean waves as a prototypical random environment, and carry out simplified, linear motion and force analysis for marine structures and vehicles. For teaching, I augment these notes with presentations that include some machine elements, fatigue, current navigation technology, and other topics. A separate compilation of solved homework problems is also made available, in the hopes that a) students will find a quick ramp-up to the problems of interest, and b) I can keep coming up with interesting problems! Finally, the class has an intensive, hands-on laboratory project in design of a field-able robotic system.

I will be grateful for any corrections, and for suggestions that will improve these notes.

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