DIY: Mini Magnetically-Levitated Trains

MIT ESP - Summer HSSP 2023
Course Instructor: Adam Kim

Course Objectives

This course presents a broad introduction of the various engineering disciplines involved in designing linear actuators, whose working principles are employed in magnetically-levitated (maglev) trains and other electromechanical devices all around us today. By taking this course, students will be exposed to a multidisciplinary design framework for applying the knowledge they learn in their respective physics and math classes to develop a functioning linear actuator via a structured, well-informed design process. Students will also gain insight on how different engineering disciplines come together to develop an engineering system.

Course Expectations

The emphasis of this course is on developing physical intuition for actuator design, not on problem-solving strategies for physics problems. However, students should be familiar to some extent with high-school level physics (mechanics and electromagnetism) and the relevant math skills to solve basic physics problems. While a brief review of these topics will be provided in the first week of class, students are encouraged to self-study and review physics topics that they are unfamiliar with and come prepared to class with questions they may have.

Course Structure

Class will usually start with a Q&A session for content previously covered or any questions that students may have, as well as a brief review of any "homework" assigned the previous week. Most of the class time will be spent discussing new topics for the week, with a 5-minute break in the middle of the class. Examples and case-studies may either be discussed in class or assigned as homework. Completing homework, if assigned, is completely optional, but students are highly encouraged to at least read through the assignment as we will go through solutions during class. Reading assignments may also be recommended to help reinforce the concepts introduced in the class, or to further supplement the materials covered in class.

Course Schedule

In the first three weeks of class, we will cover the fundamental physics for linear actuator systems; the next two weeks of class we will discuss basic tradeoffs between electromagnetic, mechanical, and thermal designs for linear actuators, and walk through the design of a working maglev train prototype. In the last week of class, we will finalize and demo the maglev prototype design, and discuss its performance as well as potential ways to improve its functionalities.

Week 1 (07/09/23): Introduction of Maglev Trains, Review of Electromagnetism Theory

Week 2 (07/16/23): Electromagnetism Theory (cont.): linear permanent-magnet motors

Week 3 (07/23/23): Electromagnetism Theory (cont.): linear induction motors

Week 4 (07/30/23): Relationships and tradeoffs between electromagnetic design and mechanical design

Week 5 (08/06/23): Relationships and tradeoffs between electromagnetic design and thermal design

Week 6 (08/13/23): Demonstration of a working mini maglev train prototype, Discussion on how sensors and control design can improve the prototype performance