ECE 470 MIDTERM #1 Info and Sample Questions Fall 2021

Please read the following information carefully and start preparing for the exam.

Time and place. The first exam will be held on Thursday, October 07, *during class time* (12:30–13:50). The exam will be on Gradescope. You will have to be logged in on the class Zoom channel with your camera set-up to show your workspace. There is no conflict exam offered at any other time.

Topics covered. The exam will cover everything up to and including the Sept 28 class, not including URDF, Jacobians, and velocity kinematics. The main reference is the textbook. Material from the textbook *not* mentioned in the slides can be skipped. Here is a list of topics:

- Configuration space and degrees of freedom: When are constraints independent, when are they holonomic, when are they non-holonomic. Grübler formula.
- Rigid body motion: rotation matrices and homogeneous transformation matrices. How to change coordinates. How to rotate and translate a frame.
- Exponential coordinates for rotations and for homogeneous transformations: Be able to compute a twist and the exponential of a twist. Rodrigues formula.
- Forward kinematics: the product of exponential formalism and the Denavit-Hartenberg formalism.
- Changing frames to represent end-effector position, wrenches and twists. The Ad operator.

What to bring. The exam is open-book. You should use a self-prepared sheet of notes. A calculator will not be necessary or helpful, but you can use a simple, non-graphic calculator. Use of phone, Internet or any communication device is not allowed.

Tips for preparing. The primary goal of the exam is to test your understanding of the main concepts, not memorization or computational skills. Make sure to follow up on all lecture material, readings, and homework problems and solutions.

Sample questions

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1. Exercise 2.8 and 2.11

2. Given a mechanism described with joint coordinates $\theta_1, \ldots, \theta_4$, are the following constraints holonomic or non-holonomic? Justify your answer.

1. $\theta_1^2 + 3\sin\theta_2\theta_3 - 1 = 0$
2. $3\dot{\theta}_1\theta_2 - 2\theta_3\dot{\theta}_4 = 0$
3. $\dot{\theta}_1\theta_1 + 3\dot{\theta}_2\theta_2 - 1 = 0$

3. Exercises 3.2, 3.32

4. Exercise 4.9. Also provide the DH frames and parameters for the mechanism.