ROB 311: HOW TO BUILD ROBOTS AND MAKE THEM MOVE

Professor Rouse, University of Michigan, Fall 2022

Homework 1

Name: ________________________________

Due September 15th at class start (12:00 pm) on Canvas. Create a single PDF that includes concise, clear answers to the questions with plots. Paste your MATLAB or Python code as the last pages of your document, and together with your m-files, upload as a .zip file.

Q1: You must complete Basics I & II completed through the Wilson Center. You can tell them you're planning to use the Robotics Makerspace, which circumvents the need to complete the project as part of Basics II. You're welcome to complete the project (and it would give you helpful skills with subtractive manufacturing), but this class will focus on the rapid prototyping tools (3D printers, laser cutter, etc.), for which there is not yet a project-based training. More information and signup is available here. Note that everyone must also do the onsite training in the Robotics Makerspace with Alyssa Emigh (aemigh@umich.edu). Everyone should have completed this during Lab 1, but if not, please complete by the HW due date.

Q2: An ideal transmission scales _____________ and _____________, such that the product of the two is ___________. They are used when its advantageous to have the mechanical power scaled, which stems from most (input) mechanical power sources operating at much higher ___________ and lower ________, compared to the output requirements We have modeled non-ideal transmissions by including in ______________ term that reduces the _____________ transmitted.

Q3: In an ideal brushed motor, the torque constant and back-emf constants are ________________.

Q4: For electric motors, torque is often considered to be approximately proportional to ______________, while velocity is approximately proportional to ________________.

Q5: Determine plots for the required motor torque, velocity, current, and voltage for the following task: A motor interacts with an inverted pendulum with point mass m (shown below). The motor applies a torque τ through a transmission ratio N, and output stiffness k and damping b can be modeled as rotational, applying torque about the base. You can use the small angle approximation to linearize the system and the task is to oscillate the pendulum at 1 Hz to 4°. We have provided an input theta vector to import, as well as a function to facilitate taking numerical derivatives (ddt.m). You have access to a maximum of 8 V and 4 A, what is the desired transmission ratio? Justify your selection and begin with Newton's 2nd Law.

$L = 1\,m$
$k = 20\,Nm/rad$
$b = 5\,Nms/rad$
$m = 5\,kg$
$k_t = 0.08\,Nm/A$
$\eta = 0.8$
$J = 0.0001\,kgm^2$
$R = 2\,Ohms$
$L = 0.0002\,H$
$B = 0.001\,Nms/rad$
$N = ?$