ROB 311: HOW TO BUILD ROBOTS AND MAKE THEM MOVE

Professor Rouse, University of Michigan, Fall 2022

Homework 2

Name: _____

Due October 4th 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 code, Python code, and any other documents as the last pages of your assignment, and together with all your files, upload as a .zip file.

Q1: The greatest factor limiting the performance of robotic actuators is their ability to dissipate _____.

Q2: In thermal systems, temperature is analogous to _____ and _____ is analogous to current.

Q3: In thermal systems, there are two types of resistances. The heat flux is proportional to the _____ resistance, whereas the temperature differences are proportional to the _____ resistances.

Q4: A T-motor U8 motor applies 1 Nm of torque during stall. What is the steady state temperature of the windings and housing? Bonus: plot temperature as a function of time.

$R = 0.19\,\Omega,\ R_\sigma^{wh} = 0.5\,\frac{\mathrm{K}}{\mathrm{W}},\ R_\sigma^{ha} = 4.3\,\frac{\mathrm{K}}{\mathrm{W}},\ k_t = 0.14\ \mathrm{Nm/A},\ \tau_\sigma^{wh} = 12.9\ \mathrm{s},\ \tau_\sigma^{ha} = 548.5\ \mathrm{s},$

Q5: Locate the thermal resistances for the winding-housing and housing-ambient systems for a Maxon RE30 60W motor with graphite brushes. Hint: find it from the catalog page / downloadable materials from Maxon's website.

$$R_\sigma^{wh} = \_\_\_\_\_\frac{\mathrm{K}}{\mathrm{W}}, \quad R_\sigma^{ha} = \_\_\_\_\_\frac{\mathrm{K}}{\mathrm{W}}$$

Q6: Consider heat flux being linearly increased as it heats actuator mass. Assume there is no heat flow out of the material (so, just a thermal capacitor). The heat flux is increased from 0 W to 10 W over 10 s. The actuator's thermal capacitance, C_σ, is 52 J/K. What is the rise in temperature of the actuator over this 10 second period?

Q7: You would like to use an FDM printer to create a part for a robot, and are choosing between ABS and PLA materials. You would like the part to be strong, impact resistant, and heat tolerant. Which material should you choose and why?

Q8: The Creality Ender 3 printers in the FRB Makerspace use 1.75 mm filament. Calculate the length of filament needed to produce the ROB311_Ball-Bot_Leash_Attachment.STL?

Q9: Two .STL files have been uploaded to the Homework 2 folder. Select either the ball-bot keychain or Open-Source Leg .STL. Slice the .STL file using Cura (or other software) to generate G-code. Please turn in the .gcode file and it will be parsed for correctness.

Q10: Create a 3D PDF of any solid model / assembly you find online (e.g. GrabCAD). You can create a 3D PDF by saving from Solidworks and selecting '3D PDF' from the saving options. Also please provide the URL where the part was obtained.