Practical Uploadable Problem Set # 3: Machine Design Specification

Remember when doing this problem set:

- Problems must first be completed *individually*, and then *group effort* starts with peer review, then:
  - With your Peer Review Evaluation Partners and no talking, review each other’s work.
  - THEN discuss and make changes as needed.
- *It is important the teacher see the original work, the PREP comments and then any changes needed.*
- *All math should also be done with a spreadsheet or Matlab script, so you can easily play “what if”.*

**Problem (Opportunity!):**

Think of the machine you want to design, build and own as the term project in this class.

1. State the problem to be solved, what else exists, and why you think you should design a new machine (even if just for fun). (1 pt)
2. State the Functional Requirements and specifications for your machine, with the understanding that other than three stepper motors and the Arduino control board and stepper motor drivers, each student has to scrounge up their own materials. (1 pt)
   a. Remember to also consider important details
      i. Safety is a critical part of design to be considered from the beginning!
      ii. Seals, bellows, wires, cutting chips, fixturing...
3. Embody the FRs in a FRDPARRC table for your machine (where a lot of the entries of course will be blank, but as your design progresses you can fill them in). (1 pt).
4. What are the forces the machine has to withstand? (1 pt)
   a. If a cutting machine, think of the power of a similar machine, the speed of the spindle, and diameter of the tool to estimate forces...
5. Given the desired accuracy of the machine, what is the required stiffness? (1 pt)
6. Assume the structural loop length of your machine is three times the sum of the distances each axis must travel, to get a feel for the structural loop: (2 pts)
   a. What is the size of a cantilever beam (tube cross section) whose length is the length of the structural loop?
      i. State your assumptions on proportions.
      ii. Assume tube outer dimension is 1/5 the length, and wall thickness 1/20 the diameter.
   b. What is the size of a C-shaped (curved beam 180 degree segment) (tube cross section) whose length is the length of the structural loop?
      i. State your assumptions on proportions.
      ii. Assume tube outer dimension is 1/5 the length, and wall thickness 1/20 the diameter.
   c. If the mass of the machine is N x the mass of the tube, what is a first order estimate of the natural frequency of your machine as a function of N (plot it).
7. Sketch stick figures for different strategies you now envision for solving the problem. (1 pt)
   a. Use the basic starting FRDPARRC and enter more detail for each strategy
   b. Apply Error Apportionment for different strategies
8. Create geometric error budgets for “top” strategies. (2 pts)

*Peer review can be done along the way or at the very end after all the individual elements done. The former is suggested*