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EGR 7040 – Design Optimization
HW #1

1. **Describe the overall process of designing systems:**
    a. Design is typically an iterative process. This includes a preliminary design generated based on previous experience and analysis. Once the preliminary design has been sufficiently modified to meet design criteria the iterative process stops and the current design is accepted to move forward in the design process. This does not imply that the selected design is optimum. The goal of design optimization is to not only select an acceptable design but to also optimize its performance based on critical input design variables.

    Design process can be described via an evolution model, which is divided into 5 main sections:

    - **Initial step** of the design process it to develop a statement of requirements (SOR). This initial SOR implicates a broad range of specialties which include but are not limited to design, sales, engineering, manufacturing, marketing, and shipping. At this stage there is significant interactions between all the aforementioned groups to insure all specifications are identified. Once the SOR is completed one can move to the next step.
    - In **second step** each of the applicable groups will evaluate the SOR to determine the goals they are tasked to achieve. Speaking specifically from an engineering perspective this requires the development of multiple preliminary designs, each of which will be evaluated against the SOR requirements. At the end of this step few promising designs are selected for additional evaluation and analysis.
    - In **third step** the objective is to develop a detailed design that will meet all of the SOR requirements. Furthermore it is desirable at this stage to optimize the performance of the selected design via accepted optimization techniques. At the end of this step, detailed 3D models and drawings are developed.
    - In the **fourth step** drawings and 3D models are used to develop prototypes. It is very likely that considerable capital is required to manufacture the necessary tooling in order to construct the desired engineering system. Therefore, it is crucial that due diligence is carried out in the first 3 steps in order to minimize the risk of tooling modifications and scrap. This step may not be required for all engineering systems but is necessary if hardware testing of any sort is required.
    - In **step five** the developed prototypes are tested to determine if the designed system meets the SOR requirements. If all goes well the design will pass testing process and be cleared for mass production. If not, then

the design requirements must be modified by going back to previous steps as required.

2. **Distinguish between engineering design and engineering analysis activities:**
    a. The analysis process is concerned with determining the response of a system that is already known. The system is known because in order to carry out meaningful analysis one must know the size of all the components, their interactions, and material properties. On the other hand, the objective of the engineering design is to estimate sizes of the components and their interactions. In other words the final design is not know at this stage. Design is an iterative process where a system is conceived and analyzed to determine if it meets the requirements. If the subject design passes the criteria the design process can be stopped at this stage. On the other hand if the system fails to meet requirements one must go back and modify the design and reanalyze to determine if the modified system meets the performance criteria.

3. **Distinguish between the conventional design process and the optimum design process:**
    a. Conventional design does not require a formulation of the objective function. As a result majority of the design decisions are guided by the designer in charge of the system. This leaves the system susceptible to the limitations of the individual in charge based on experience, intuition and quality of data gathered. In contrast, development of the initial optimization function is used to drive the final design via optimization concepts, which are more objective and formal in application.

4. **Distinguish between optimum design and optimal control problems:**
    a. Optimum design requires the definition of an objective function for a given system design. Once the function is optimized and system designed per optimization methods the design remains fixed for the remainder of if useful life. Optimum control utilizes control loops in order to monitor system output and attempts to ensure optimum system performance by adjusting controllable parameters in order to ensure optimum system output at any given time.