

**MECHANICAL ENGINEERING DEPARTMENT
CLEMSON UNIVERSITY**

**Ph.D. Qualifiers Examination in
ENGINEERING DESIGN
Spring 2010**

The study guide stated that to be successful on this exam, you must demonstrate that you know:

- How to formulate a problem,
- How to sketch and understand engineering drawings (projections),
- How to obtain order of magnitude results (approximate analysis),
- What next steps you would take to get to a more in-depth solution,
- How to identify failure criteria and assess failure,
- How and when to perform optimization,
- Component design (we will use the design of shafts to examine your fundamental knowledge).

You should show analytical insight through design solutions that exhibit the level of maturity and understanding expected of Master's level students. Remember that there is not a single correct solution, but we are interested in seeing your thought process

The problem we are asking you to consider is the following:

The figure below is that of a conceptual drawing of a winch designed to be used in various situations, including corrosive environments and carrying hazardous material. The winch capacity is 120 lbs, and the rope used has a diameter of $\frac{3}{4}$ in, a minimum breaking length of about 8,000 lb and a spring constant of about 50,000 lb/in per ft of length in axial tension. The lift height is typically three floors (24-30 ft).

Formulate the problem that led to this design. (why is it configured in this way?) What are the assumptions and how would you proceed to design the shaft that supports the winch drum?

Identify the strong and weak points of the overall design (justify each).

How would you address the most critical of the weak points you identified?

Considering the overall design, how would you modify it to ensure greatest safety?

Give a detailed design (drawing and calculations procedures) of the shaft supporting the drum.

