

# GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff  
School of Mechanical Engineering

**Ph.D. Qualifiers Exam - Fall Quarter 1997**

Design

EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

- Please sign your name on the back of this page—

**George W. Woodruff School of Mechanical Engineering  
Georgia Institute of Technology**

**DESIGN QUALIFYING EXAM**

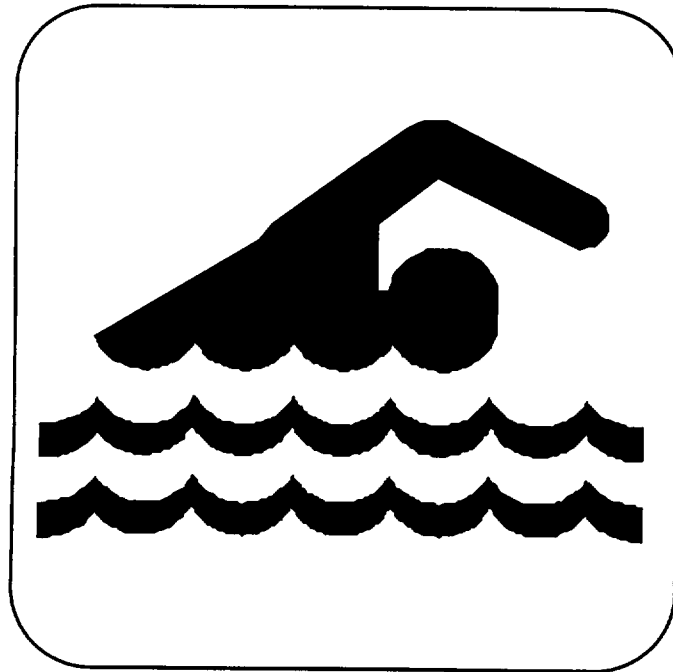
**Fall 1997**

We are interested in learning what you know and your ability to reason in the formulation and solution of design problems. If you find the question or any part of this exam confusing, please adjust the question, explicitly rephrase it, and state your assumptions.

Read the entire exam first. Please spend equal amounts of time on each of the three parts of the exam: Realizability, Analysis, and Methods.

**ORALS**

We will conduct the oral exam by first giving you the opportunity to state how design fits into your research activities. If you do not do an adequate job on this written exam, we may ask you to discuss it during the oral exam.



**PROBLEM STATEMENT**

After turning in a good, but not great, showing during the Olympics, the swim team coaching staff decides that some changes in the training regimen are in order. The issues that they believe need to be addressed include:

1. the ability to fine-tune each practice session in terms of level and duration of athlete exertion, and
2. the necessity to promote good swimming form.

For these reasons, the coaching staff decides that they need a swimming machine that can be controlled during practices, something that does not require a large swimming pool. The machine should also enable the capture of swimming motions and, if needed, the control of those motions.

You have been hired as a consultant to determine the feasibility of developing such a machine. The machines must be safe, reliable, durable, enable at least two different swimming strokes to be performed, and require less maintenance than a typical swimming pool.

For your consultants report, the coaching staff asks that you address the following topics.

### **Realizability**

- a) Develop an initial set of design specifications for the swimming machine. Choose two swimming strokes, the set of arm, body, and leg motions, etc. Develop a function structure for your system. Show how your functions can be grouped into subsystems. Define the interfaces between your subsystems, as objectively as you can, in terms of material, energy, and signal/information flows.
- b) Select a key subsystem and generate 3 concepts for it. Identify the physical principle upon which each is based. Evaluate these concepts based on your design specifications and select one for further design.
- c) Perform further design on the selected concept. Provide a layout sketch of your design and label the main components and modules. (Note: we are looking for your ability to embody your conceptual ideas, not for a comprehensive design. We are looking for enough detail to answer Parts (d) and (e).)

### **Analysis**

- d) Explain what analysis methods you would use to assess the results of your detailed design from part (c). Keep in mind your specifications. Outline your approach to developing an appropriate analysis model for this design.
- e) Do the components in your system need to be designed for infinite life? Why or why not? Reason in terms of expected loads, number of cycles, etc.

### **Method**

- f) Critically evaluate your design process. If you had two weeks, instead of two hours, what would you have done differently?
- g) What are some of the root assumptions and limitations for the successful application of your design methods? Of your approach to concept selection? Does your approach on this exam scale to the consultant's scenario? Why or why not?

Ground your responses to (f) and (g) in a recognized approach to design (e.g., Pahl & Beitz, the Decision Support Problem Technique, etc.).