GEORGE W. WOODRUFF SCHOOL OF MECHANICAL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

DESIGN QUALIFIER

FALL 2007

WRITTEN EXAMINATION

We are interested in learning what you know and your ability to reason in the formulation and solution of design problems.

If you find any question or part of this exam confusing, please state your assumptions and rephrase the question and proceed.

Please read the entire exam first.

Questions 1 and 2 carry equal points. Both have multiple parts.

Allocate your time carefully so that you cover all three parts that you are being examined on in these two questions, namely, Methods, Realizability and Analysis.

A document containing some formulae is available for you to use in answering Question 2

ORAL EXAMINATION

Please arrive half an hour before the scheduled time for the oral exam. During this period we will give you a question to think about. The scope of the oral exam is as follows:

* provide an opportunity for you to state how design fits into your research activities;
* probe your understanding of the question that we posed to you in the preceding half hour.

QUESTION 1 – METHOD & REALIZABILITY

THE PROBLEM

US adventurer Fossett is missing

An extensive search has been launched for record-breaking US adventurer Steve Fossett, who went missing in his airplane in the Nevada desert.

Many adventurers, such as Steve Fossett, occasionally get into serious, often life threatening trouble while pursuing their hobbies. Aircrafts crash over uninhabited land, rock climbers fall into crevices; skiers get buried by avalanches, etc. Due to the recent headlines regarding the disappearance of Steve Fossett over Nevada, an increased interest in Life-Saving Devices (LSDs) transmitting geographical position and other data has emerged. Although such devices are readily available, they often fail to transmit data after a certain amount of time due to lack of power.

Corporations in the rescuing industry are interested in the development of human-driven power supply which may prevent transmitters from failing to operate. Your task is to design a human-driven device that produces enough electricity to power a LSD with an electricity consumption similar to a cell phone. The equipment that you design will have two purposes—to immediately feed the electricity generated into the LSD and, alternatively, to recharge a set of batteries that are supposed to drive the LSD.

HUMAN-DRIVEN LSD POWER SUPPLY AND CHARGER

Each time an adventurer embarks on an undertaking, he/she must be prepared to face life-threatening problems. Since accidents are usually unpredictable, adventurers must wear their LSD at all times. To give adventurers more piece of mind, a particular rescuing organization has commissioned you to design a "Human-driven Power Supply and Charger for LSDs" (HDPSC).

Task

Assume that you are in charge of the design team responsible for developing a human-driven power supply and charger for LSDs. Speculate about the events faced by an adventurer in trouble and include the following considerations in your design.

- What is the function structure that provides the most flexibility for designing human-driven power supplies/chargers for life-saving devices?
- What are the components of your human-driven power supply and charger?
- How can the electricity required be generated?
- How can the power supply/charger be operated in very different climates?
- How can electricity for the power supply/charger be generated while the adventurer is asleep or unconscious?

Deliverables

Method

1. *Clarify the Task:* State the overall function of your system in solution neutral terms. What are the most important drivers/design criteria? Define a design requirements list.

2. *Conceptual Design:* State and implement the steps (including functional diagrams/decomposition) for transforming the overall function that you have identified into at least three alternative design solutions. Ensure that you have identified the important sub functions. Sketch and describe the workings of these alternatives.

3. *Selection:* Suggest a structured approach to select one of the alternatives for further development.

Realizability

4. *Embodiment:* Further develop the alternative that you have selected.

5. *Costing:* How would you estimate the cost of your design? You may critically evaluate the design in terms of manufacturability, initial cost, maintenance cost, reliability, manipulation performance, and other criteria that you feel are important to consider in this phase of design.

6. *Pricing:* Based on the preceding analysis, how would you estimate the market size for such a system and set the price for selling such a system? Be brief.

Name _____

QUESTION 2 A - COMPONENT DESIGN ANALYSIS

Please show all your work in this paper and *number your solutions*.

An involute gear drives a high-speed centrifuge. The speed of the centrifuge is 18,000 rpm. It is driven by a 3000-rpm electric motor through a 6:1 speedup gearbox. The pinion has 21 teeth and the gear has 126 teeth with a diametral pitch of 14 per inch. The width of the gears is 1.8 in. and the pressure angle is 20°

Calculate: Circular pitch (P_c), center distance (C), pitch circle radii, base circle radii, outside radii, and contact ratio. **Note that the radii are for those of gear and pinion. (5 pts)**

2B. Please write a complete descriptive answer in the space provided.

a). Why are washers used in bolted connections? Give two reasons. (0.5 pt.)

b). What are two differences between Shields and Seals in roller bearings? (0.5 pt.)

c). In which types of applications should squared and grounded ends of springs used? Why? (0.5 pt)

d). Explain the meaning of Conjugate Action (0.5 pt.).

e).What is the property of the Angular Velocity Ratio (m_v) between gears in a gear set? (0.5pt.)

f). Why are the ends of torsion spring coils extended tangentially? (0.5 pt.)

g). What is the effect of undercutting and interference on gear tooth? (0.5 pt.)

h). Why is it desirable to have Contact Ratio, $m_p > 1$ in gears? (0.5 pt.)

i). Is buckling an issue with extensions spring? Please explain (0.5 pt.)

j). Explain the meaning of Basic Load Rating in roller bearings. (Dynamic Capacity) (0.5 pt.)