Department of Mechanical Engineering
University of Saskatchewan

ME492.3 Materials in Engineering Design

FINAL EXAMINATION (CLOSED BOOK, GROUP)

Instructor: I. N. A. Oguocha **Date: 14th April 2009**

This Group Examination carries one-half (1/2) of the final examination grade.

Instructions

1. Answer ALL Questions **TIME ALLOWED**: 1 HOUR 40 MINUTES
2. FOUR **Help Sheets** are allowed. **Course textbook is also allowed.**
3. Show details of all calculations where required or necessary.
4. All necessary charts, tables, tables are provided. Return all used charts with your script.
5. Attach all CES printouts used to solve the questions
6. Write the name of your group and the names of your group members on all scripts and printouts submitted. Ensure that each member signs off against his/her name.

QUESTION #1: DISPOSABLE COFFEE CUPS (260 Points)

It is increasingly recognized that the use of materials in engineering carries environmental penalties: pollution of water and air, solid waste, consumption of non-renewable resources and more (collectively called *eco-damage*). One response is to adopt, as a design objective, the minimization of this damage.

Consider, as an example, the replacement of an existing disposable cup (**Figure Q1 in the Group Worksheet**) by one which is more environmentally benign. The environmental impact it causes is difficult to quantify. One component of impact relates to the energy content of the material: many aspects of impact (CO_2 emissions, air-borne particulates) are proportional to this. And energy content (H) can be quantified, at least approximately. We shall use it as a measure of environmental impact, to illustrate how it can be balanced against cost.

Disposable cups are not, at present, recycled, so the energy and material they contain are irretrievably lost when they are discarded. To minimize the eco-impact (measured now by energy content), we seek the design which incorporates the least energy to start with. But disposable cups must also be cheap. So we find two conflicting objectives: the environmental goal of minimizing energy content (H), and the economic one of minimizing cost (C). There are constraints which must be met: (i) the stiffness constraint requires that severe ovalization must be avoided when the cup is picked up (or loaded) across a diagonal as shown in the figure. The critical stiffness for onset of unacceptable ovalization is designated S_c. (ii) it would be desirable, too, that it also insulates (**Table Q1 in the Worksheet**).

Questions

(a) Derive the appropriate material indices for selecting materials for the cup based on the specification given above. Follow the method described in class (i.e., describe function(s), objective(s), measure of performance, design variables, constraints and constraint equations, and so on). State any assumption(s) made to simplify your analysis. (80 Points)