ODE	**FINAL PROJECT REPORT** GUIDELINES FOR PREPARATION
ME 555 **DESIGN OPTIMIZATION**	**PANOS Y. PAPALAMBROS** **WINTER 2004**

1. General Format

The report must be prepared in a form suitable for electronic transmission. Complicated algebraic manipulations in the appendices may be handwritten and scanned. Figures, tables and equations must be numbered. Figures and tables must each have captions. Printing of text must be at 1 1/2 space with 1 inch margins and the type font size should be similar to the one used in these guidelines (12 point Times).

The report must be submitted electronically at the course website along with one hard copy printed single-sided and loose-leaf. Please do not bind it! Please use the cover page template supplied at the end of these guidelines.

2. Content Format

The report must contain the items described below to be acceptable. The sequencing of sections may change after the model development depending on the individual projects. Also, there may be a variation in the length and effort required in particular sections.

1. <u>Cover Page and Abstract</u>

This contains, in a <u>single page</u>, the title of the project, your name and date, and an <u>abstract</u> of approximately 200 words describing your problem and the results obtained. Do <u>not</u> write generalities but be specific about <u>your</u> work.

2. <u>Table of Contents</u>

A list of all sections, subsections, appendices, etc., contained in your report.

3. <u>Problem Statement</u>

As in the proposal/interim report (following the *Optimization Checklist* in Chapter 8 of your textbook), with any needed modifications.

If you are designing a system composed of several subsystems, state the overall system problem and identify the individual subsystems you will first optimize separately, and the rationale for selecting these subsystems. Please note the individual that worked on each subsystem.

4. <u>Nomenclature</u>

Define all symbols that you use, particularly for the mathematical model development, as should have been provided in your proposal/interim report. If you have several subsystems, you should make sure you use a consistent nomenclature and set of symbols. It may also be convenient to divide the symbols list to subsystems.

The following sections 5-9 should be done for each subsystem separately. For some projects, sections 8 and 9 may be more suitable for inclusion after the system integration study in section 10.

5. Mathematical Model

This is the section provided in the proposal/interim report, with any needed corrections. The last part of this section must summarize the model, give list of variables, number of equality and inequality constraints and number of degrees of freedom. Since it is likely that the final model evolved from its original statement, you should describe briefly how the model evolved and what made you change it. If the changes were a result of the optimization study itself, you may include these modeling decisions in the later section on optimization study (Section 7 below). Relegate to appendices any lengthy explanations you feel you need to include, so that the overall report flow is not disrupted.

6. Model Analysis

This section describes any possible bounding agreements, monotonicity properties and tables, constraint activity identification, model transformations and simplifications, scaling, case decomposition and anything else you have done to make the problem easier to solve numerically and/or analytically.

It is suggested that model analysis may be first described for a specific set of parameter values and then generalized to other parameter values to the extent possible.

7. Optimization Study

Identification of the solution and a description of how it was obtained should be presented. Unsuccessful attempts should be reported and documented in an appendix.

The solution should not be given as just a set of numbers. Other issues must be examined and described, e.g., constraint activity, values of multipliers, interior vs. boundary solution, global vs. local results, numerical stability, satisfaction of KKT conditions, different starting points.

Results obtained numerically should motivate attempts for analytical verification. Examine and explain, for example, if monotonicity analysis results agree with numerical results.

8. Parametric Study

The solution should be obtained for different sets of parameter values. Does the optimum change? Can the results be generalized? Are there ranges of parameter values that may dictate the type of solution expected?

9. Discussion of Results

Here, the results of the optimization study are given with an engineering interpretation. What are the design implications? Can you identify a "design rule" for an optimum solution? Do the results make sense? How does the model limit the solution? Are there "practical" constraints active and what would this imply? What would you do next to improve the answers or make the problem more interesting?

In a system design study, you must identify any conflicting requirements stemming from optimizing the subsystems separately. Do the subsystems have common variables, parameters, objectives or constraints? Are some variables in one subsystem parameters in the other? Is there an expected sequence of solving one subsystem before you solve another?

10. System Integration Study

In this section you examine the issues you raised in Section 9 regarding the linking of the subsystems. Can the combined subsystem optima give you the overall system optimum or are there conflicts to be resolved? In the latter case you must attempt the following:

(a) Select a system objective and combine all variables and constraints into a single optimization model. Solve this overall system problem as a single optimization problem. This is what we call the All-at-Once (AAO) approach. If you can obtain a solution, compare it with the solutions you obtained from the subsystems. Discuss your results.

(b) The AAO approach may give you a problem that is too complicated and you cannot obtain numerical results, and a decomposition method is applied. Identify the problem partition into subproblems, each with their own local variables. These may be just the subsystems you identified in your earlier individual studies. Further, define a *master* problem with an appropriate objective that has as design variables the *linking* variables among the subproblems. Apply a coordination strategy where the master problem is solved wrt the linking variables (local variables fixed) and the subproblems are solved wrt the local variables (linking variables fixed). Examine how the coordination strategy terminates.

(c) Even if you do get results from the AAO strategy, you should perform the study in (b) and compare the results you get from the two approaches.

11. References

Complete reference list of any sources that you used to complete your project.

12. Appendices

There may be several appendices containing anything that would distract the reader if used in the main text, for example, elaborate algebraic manipulations, proofs of monotonicities, coding of the models, and selected computer runs.

Final Note: Your report should be a high-quality piece of work similar to technical papers, something you should be proud of. In fact, several student reports have resulted in scientific publications in the past. In any case, you should remember that others must be able to read, understand and duplicate what you have done with only the information contained in your report.

If you are interested in pursuing a technical publication of this work please contact me at the end of the term.

OPTIMAL DESIGN OF A TURBOENCABULATOR

by

Smart M. Grad
Nice E. Ugrad

ME 555-04-00
Winter 2004 Final Report

ABSTRACT