UNIVERSITY OF MANITOBA

**DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING**

# 24.767 OPTIMIZATION METHODS FOR COMPUTER-AIDED DESIGN

## ASSIGNMENT 2

**Due Date: February 22, 2005** **Instructor: J. LoVetri**

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**General Instructions**: This assignment is to be written up neatly since messy work will not be marked. All programs which are written for the assignment are to be fully commented and included in an Appendix at the end of the assignment. Relevant program output used to answer a question is to be transferred into tables which should be included in the main body of the report at the location where each table is being referred to.

1) The fuel consumption of a diesel engine powering a nonlinear load varies with the speed of operation. The throttle dial can be set from 1 to 2 [krpm] in steps of 1.0 [rpm].

   (a) What is the scheme which will find the minimum fuel consumption quickest given that it is a unimodal function?

   (b) What is the number of throttle settings which will be required to find the minimum fuel consumption setting within an interval of 10 [rpm]?

   (c) Determine what the throttle settings would be during the process of using this scheme if the minimum fuel consumption occurs at 1995 [rpm].

2) Minimize the function $f(x) = 10^{-4}x^2 + e^{-10^{-8}x^2} + 10^{-2}|x - 10|$ using 4 function evaluations with a) the Fibonacci search and b) the Golden section search. Tabulate the function value at each evaluation point and the interval of uncertainty after each step.

3) Write a program to bracket the minimum of the objective function: $F(x) = e^{-x} + x^2$. The algorithm should use a combination of *quadratic extrapolation* and a *maximum step magnification* technique. Start the algorithm at the point $a_1 = 1$ using an initial step of $\Delta = 0.01$ (*i.e.* $b_1 = 1.01$) and a maximum magnification of 3.0. You may use the subroutine **mnbrak()** from [1] or you may write your own code. Tabulate the interval of uncertainties searched and for each step state whether quadratic extrapolation or a maximum magnification was used.

4) Write a program for the *Golden Section Search* to refine the interval of uncertainty found in question (3) to $b_{k+1} - a_{k+1} < 10^{-4}$. Tabulate the intervals for the first and last few step in the reduction. The subroutine **golden()** [1] is appropriate or you may write your own code.

5) Do Q7.7 and Q7.8 in the textbook [2].

6) For the objective function:

$$F(x) = e^{x} + 0.01/x \ .$$

Write a program to find the minimum using the Newton-Raphson technique. Specify a reasonable stopping criterion. Compare with the use of the secant method program implemented in Q7.8 of the textbook.

**References**


[1] W. H. Press, B. P. Flannery, S. A. Teukolsky, W.T. Vetterling, *Numerical Recipes in C: The Art of Scientific Computing*, Cambridge University Press, 1988.

[2] E. K. P. Chong, S. H. Zak, *An Introduction to Optimization*, 2nd Edition, John Wiley and Sons, Inc., 2001.