Department of Mechanical Engineering
Indian Institute of Technology Madras
**Optimization Methods for Mechanical Design (ME7223)**
Date: 29-Oct-2021 **Assignment - 3** Maximum Marks: 20
Instructor: Dr. Ratna Kumar Annabattula

| Question: | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Points: | 6 | 1 | 8 | 5 | 20 |
| Score: | | | | | |

Note: Write MATLAB codes for all the methods to be used.

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1. Minimize the function

$$f(x_1, x_2) = 100\left(x_2 - x_1^2\right)^2 + (1 - x_1)^2$$

using the following:

(a) Random walk method with direction exploitation, using an initial guess of your choice. [1½]

(b) Univariate method. [2]

(c) Conjugate directions (Powell's) method. [2½]

Use an initial guess $\mathbf{X_1} = \begin{Bmatrix} -0.5 \\ 0.5 \end{Bmatrix}$ for the Univariate and Powell's methods. Plot the contour lines of the objective function and superimpose the directions along which algorithm progresses for all the methods. Repeat the exercise using 2 additional initial guess points of your choice for both the Univariate and Powell's methods.
**Note**: You are encouraged to try out various initial guess points, and based on your experience, present the ones which you find interesting. You are also encouraged to comment on the differences (if you find any) in which the algorithm progresses based on the choice of your initial guess points.

2. (a) Compare the number of steps taken by the Univariate and the Powell's methods in question 1, for the choice of parameters you've taken (initial step length etc.). [½]

(b) Comment on the differences in which the Powell's method progresses for the two objective functions: [½]

$$f(x_1, x_2) = (x_1 + 2x_2 - 7)^2 + (2x_1 + x_2 - 5)^2$$

and

$$f(x_1, x_2) = 100\left(x_2 - x_1^2\right)^2 + (1 - x_1)^2$$

3. Minimize the function $f(x_1, x_2) = 8x_1^2 - 6x_1x_2 + 8x_2^2 - x_1 + x_2$ using [8]

   (a) Steepest descent method

   (b) Conjugate gradient method

   (c) Newton's method

   (d) Marquardt method

   For all the methods, assume the initial guess to be (100,0). For Marquardt method, $a = 10^4$ where $\tilde{\mathbf{J}} = \mathbf{J} + a\mathbf{I}$ ($\mathbf{J}$ and $\mathbf{I}$ are the Hessian and Identity matrices respectively). Assume the other parameters appropriately. Perform a maximum of 4 iterations for each method and compare them in terms of final accuracy. Mark the values of the design variables on the contour plot of the objective function and tabulate the values at each step for all the methods. Commment on your observation(s).

4. Minimize the function $f(x, y) = x^2+y^2$ subject to the inequality constraint $x+2y \geq 6$ and the equality constraint $x - y = 3$ using interior and exterior penalty function methods. [5]