Holistic Numerical Methods Institute
committed to bringing numerical methods to undergraduates

Multiple-Choice Test
Chapter 09.03 Multidimensional Direct Search Method Optimization

COMPLETE SOLUTION SET

1. Which of the following statements is FALSE?
   (A) Multidimensional direct search methods are similar to one-dimensional direct search methods.
   (B) Enumerating all possible solutions in a search space and selecting the optimal solutions is an effective method for problems with very high dimensional solution spaces.
   (C) Multidimensional direct search methods do not require a twice differentiable function as an optimization function
   (D) Genetic Algorithms belong to the family of multidimensional direct search methods.

Solution
The correct answer is (B).

Problems with very high dimensional solution spaces are very large and therefore it is computationally difficult to enumerate the search space.

2. Which of the following statements is FALSE?
   (A) Multidimensional direct search methods require an upper and lower bound for their search region.
   (B) Coordinate cycling method relies on single dimensional search methods to determine an optimal solution along each coordinate direction iteratively.
   (C) If the optimization function is twice differentiable, multidimensional direct search methods cannot be used to find an optimal solution.
   (D) Multidimensional direct search methods are not guaranteed to find the global optimum.

Solution
The correct answer is (C).

Multidimensional direct search methods can be used with any function to find optimal solutions. If the functions are twice differentiable there are more computationally efficient techniques for optimization of these functions.

3. The first cycle of Example 1 in Chapter 09.03 results in an optimal solution of $f(2.6459,0.8668) = 4.8823$ for the gutter design problem. The next iteration starts with a search along dimension *l* (length) looking for the optimal solution of the function $f(l,0.8668)$ as shown in Table 3 and reproduced below where $\theta = 0.8668$ and $f(x_i) = (6 - 2l + l\cos(0.8668)l\sin(0.8668))$. What is the optimal solution for the length of the gutter side at the end of iteration 10?

Iteration	x_l	x_u	x_1	x_2	$f(x_1)$	$f(x_2)$	ε
1	0.0000	3.0000	1.8541	1.1459	4.9354	3.8871	3.0000
2	1.1459	3.0000	2.2918	1.8541	5.0660	4.9354	1.8541
3	1.8541	3.0000	2.5623	2.2918	4.9491	5.0660	1.1459
4	1.8541	2.5623	2.2918	2.1246	5.0660	5.0627	0.7082
5	2.1246	2.5623	2.3951	2.2918	5.0391	5.0660	0.4377
6	2.1246	2.3951	2.2918	2.2279	5.0660	5.0715	0.2705
7	2.1246	2.2918	2.2279	2.1885	5.0715	5.0708	0.1672
8	2.1885	2.2918	2.2523	2.2279	5.0704	5.0715	0.1033
9	2.1885	2.2523	2.2279	2.2129	5.0715	5.0716	0.0639
10	2.1885	2.2279	2.2129	2.2035	5.0716	5.0714	0.0395

(A) 2.1885
(B) 2.2279
(C) 5.0715
(D) 2.2082

Solution
The correct answer is (D).

The correct solution is the average of x_1 and x_2 at iteration 10 which is 2.2082.

4. What is the maximum size for the area of gutter at the optimal point determined in multiple-choice question 3? (*Hint:* You do not need to do any calculations to answer this question)
   (A) 5.0716
   (B) 5.0714
   (C) 5.0715
   (D) 2.2082

Solution
The correct answer is (A).

The correct solution is the average of $f(x_1)$ and $f(x_2)$ at iteration 10 which is 5.0715.

5. To find the minimum of the function $f(x, y) = 5x^2 - 6xy + 5y^2 - 2$ hold $y = 0$ and use 2 and -2 as your upper and lower bounds for your one-dimensional search along the x coordinate using golden search method. What would be the optimal solution for x after the first iteration?
   (A) 3.1146
   (B) 0.4721
   (C) 0
   (D) 0.0015

Solution
The correct answer is (C).

The first two iterations are shown in the table below. The optimal solution after iteration one is the average of 0.4721 and -0.4721 which is 0.

Iteration	y	x_l	x_u	x_1	x_2	$f(x_1)$	$f(x_2)$	ε
1	0.00	-2.0000	2.0000	0.4721	-0.4721	3.1146	3.1146	4.0000
2	0.00	-0.4721	2.0000	1.0557	0.4721	7.5728	3.1146	2.4721

6. Considering the scenario in Question 5, what would be the optimal solution for x after the first iteration? (Can you explain the difference?)
   (A) 0
   (B) 0.7639
   (C) 0.4721
   (D) 7.5728

Solution
The correct answer is (B).

Based on the table shown in the solution to Question 5 above, the optimal solution after iteration one is the average of 1.0557 and 0.4721 which is 0.7639. Continuing the iterations will show that the optimal solution in this cycle for the x-coordinate is zero. While this was found in the first iteration, this is due to the fact that the midpoint of search bounds coincided with the optimal solution. In the second iteration while we do get away from the optimal solution the value of ε is smaller (as expected) indicating convergence to the optimal solution.