settings represented by your coding and count the number of schemata or similarity templates inherent in your coding.

1.3. For the black box device of Problem 1.1, design a minimal binary coding for the eight switches and compare the number of schemata in this coding to a coding for Problem 1.2.

1.4. Consider a binary string of length 11, and consider a schema, 1*********1. Under crossover with uniform crossover site selection, calculate a lower limit on the probability of this schema surviving crossover. Calculate survival probabilities under the same assumptions for the following schemata: ****10*****, 11*********, ***111*****, ****1*0****, **1***1**0*.

1.5. If the distance between the outermost alleles of a particular schema is called its *defining length* δ, derive an approximate expression for the survival probability of a particular schema of total length l and defining length δ under the operation of simple crossover.

1.6. Six strings have the following fitness function values: 5, 10, 15, 25, 50, 100. Under roulette wheel selection, calculate the expected number of copies of each string in the mating pool if a constant population size, $n = 6$, is maintained.

1.7. Instead of using roulette wheel selection during reproduction, suppose we define a copy count for each string, $ncount_i$ as follows: $ncount_i = f_i/\bar{f}$ where f_i is the fitness of the ith string and $\bar{f}$ is the average fitness of the population. The copy count is then used to generate the number of members of the mating pool by giving the integer part of $ncount_i$ copies to the ith string and an additional copy with probability equal to the fractional part of $ncount_i$. For example, with $f_i = 100$ and $\bar{f} = 80$, string i would receive an $ncount_i$ of 1.25, and thus would receive one copy with probability 1.0 and another copy with probability 0.25. Using the string fitness values in Problem 1.6, calculate the expected number of copies for each of the six strings. Calculate the total number of strings expected in the gene pool under this form of reproduction.

1.8. The form of reproduction discussed in Problem 1.7 is sometimes called reproduction with expected number control. In a short essay, explain why this is so. In what ways are roulette wheel selection and expected number control similar? In what ways are they different?

1.9. Suppose the probability of a mutation at a single bit position is 0.1. Calculate the probability of a 10-bit string surviving mutation without change. Calculate the probability of a 20-bit string surviving mutation without change. Recalculate the survival probabilities for both 10- and 20-bit strings when the mutation probability is 0.01.

1.10. Consider the strings and schemata of length 11. For the following schemata, calculate the probability of surviving mutation if the probability of mutation is 0.1 at a single bit position: ***1**0****, 1*********0, ***111*****, *1000010*11. Recalculate the survival probabilities for a mutation probability $p_m = 0.01$.