EE6227 Homework (2023S1)
All submissions are to be handwritten

1. Let n denote any positive integer greater than 1. A population of n-bit binary strings are evaluated based on the objective of maximizing the number of alternating sequences of 1's and 0's. If we denote the string as $B = \langle b_1 b_2 b_3 \ldots b_n \rangle$ where $b_i \in \{0, 1\}$ for $i = 1,2\ldots n$, the fitness evaluation function can be written as follow:

$$f(B) = \sum_{i=1}^{n-1} |b_i - b_{i+1}| + |b_n - b_1|$$

For example, for the strings 0110 and 0000, the former has a fitness of 2 while the latter has a fitness of 0 out of a maximum fitness of 4.

   a. Compute the fitness of the binary strings B_1=1011$x_4x_3x_2x_1$0001 and B_2=0101$x_4x_3x_2x_1$1101 where the value of the four binary bits $x_4x_3x_2x_1$ is equal to modulo 16 of the last two digits of your student identification number.

   $f(B_1)$ = ________________ $f(B_2)$ = __________________

   b. Comment on the suitability of the fitness function for the purpose as stated.

2. Suppose at birth, every human being is given a fixed number of heartbeats, and once these heartbeats are used up, life ends. How should one optimally use these heartbeats to have as long a life as possible? It is tempting to suggest that one is better off staying in bed and resting, to maintain a low heartbeat. However, the science of good health does point to the fact that a trained heart beats more slowly when the person is at rest. On this note, consistent exercising is not a bad idea.

   Suppose that the untrained heart beats 80 times per minute when a person is at rest, and during exercise it beats 120 times per minute. If a person exercises the fraction x of its time, the average heartbeats per minute is as follows:

$$f(x) = 120x + (1-x)g(x)$$

To determine an appropriate function g(x), we can base it on the requirement that g should be close to 80 for small x, which means that hardly any exercise is done. When x approaches 1, we assume g to be closing in on 50, meaning the person is well-conditioned. Let's assume a simple model $g(x)$ to be:

$$g(x) = 50 + 30e^{-100x}$$

Produce a table as per the format shown in Table 1 in your answer script.

   i. Fill in values for x, $g(x)$ and $f(x)$ in the table. You are free to select 20 suitable values of x to work out an approximate value of the optimum time (in minutes) for exercising.

   ii. Write a suitable fitness function $f^*(x)$ to scale the fitness values so that they are normalized from 0 to 1. Fill in the values under the column labelled $f^*(x)$ accordingly.

   iii. From an optimization perspective, justify in your own words the level of difficulty in solving for the optimum value of x.

Table 1

x	*g(x)*	*f(x)*	*f*(x)*