1) Construct a combinational circuit with a control input (x), and a 5-bit integer output ($c_4 c_3 c_2 c_1 c_0$). If $x = 1$, the output c is to be the difference of the integers $a - b$, while if $x = 0$, the output c is to be the sum of the integers $a + b$. You may use full adders and up to 4 additional gates. Draw the circuit diagram.

b) Continue the page reference string with at most 3 additional terms where OPT will result in strictly fewer page faults than LRU.

```
ref. str.:  5   3   8   4   _   _   _
            ---------------------------
            5   5   5   5
                3   3   3                   OPT
                    8   8
                        4
                    -------------------------
            5   5   5   5
                3   3   3                   LRU
                    8   8
                        4
```

c) Continue the page reference string with at most 5 additional terms where 2nd chance will result in strictly fewer page faults than FIFO.

```
ref. str.:          5       3   8           4       _       _       _   _           _
            -----------------------------------------------------------
                    5       (1) 5   (1) 5   (1) 5   (1)
2nd  chance                         3  (1) 3   (1) 3   (1)
                        8                       (1) 8   (1)
                            4                           (1)
            -----------------------------------------------------------
                    5           5       5       5
FIFO                        3           3       3
                                        8       8
                                                4
```

1) Given a (possibly empty) binary search tree of integers, write an iterative function that inserts an integer x into the tree. Do not use recursion.

2) Consider the following quicksort code to sort an array of floats. The algorithm is begun by the call quicksort (a, 0, n-1).

```
void quicksort(float        a[], int first, int last)
// Sort a[first]..a[last];  original call: quicksort(a, 0, n-         1)
{
  if (first < last) {
    int splitpt =  partition(a, first, last);
    quicksort(a, first, splitpt -              1);
```

Theory Exam

1. Give a state diagram for a deterministic finite automaton that recognizes the following language over $\Sigma = \{0, 1\}$:

   {w : w has an even number of occurrences of the substring 01 and has an odd length}

2. Answer each of the following questions with only YES or NO to indicate whether or not the following languages are decidable. Do not guess if unsure, as wrong answers will lower your score!
   Scoring: +2 points for correct answers; 0 points for no answers; -