Part I (資料結構)

1. (5 points) What are the advantages of **height-balanced** binary trees over **normal** binary search trees?

2. (10 points) Write the worst case running time (in **big-O** notation, i.e., O(1), O(log n), O(n), O(n log n), O(n^2), etc.) for each of the following operations:

    (i) searching an **unordered list** with n items; (ii) searching an **ordered list** with n items; (iii) searching a **binary search tree** with n nodes; (iv) searching a **height-balanced binary search tree** with n nodes; (v) searching a **hash table** with n keys.

3. (15 points) Draw the following trees with **minimum height** that contains the 10 numbers from 1 to 10.

    (i) A **complete binary search tree**;　　　(ii) An **AVL tree** that is not complete;　　　(iii) A **2-3 tree**.

4. (5 points) Let array A be { **3, 9, 4, 7, 1, 6, 2, 8, 5** }. What will A be after **f1(A, 0, 8)** returns?

5. (5 points) Let array A be { **3, 9, 4, 7, 1, 6, 2, 8, 5** }. What will A be after **f2(A, 0, 8)** returns?

```
void f1(int a[], int p, int r)
{
   int i, j, t, x;
   x= a[r];   i = p - 1;
   for ( j = p; j < r; j++ )
     if ( a[j] <= x) {
        i++; t = a[i]; a[i] = a[j]; a[j] = t;
     }
   t = a[i]; a[i] = a[j]; a[j] = t;
}
```

```
void f2(int a[], int p, int r)
{
   int t;
   if ( p >= r ) return;
   if ( a[p] > a[r] ) {
     t = a[p]; a[p] = a[r]; a[r] = t;
     f2( a, p+1, r );
   }
   else f2( a, p, r-1 );
}
```

6. (10 points) Write a C program, rotateRight(int A[], int n), that can rotate an array of size n right by one element. For example, rotating {1, 2, 3, 4, 5} will result in {5, 1, 2, 3, 4}.

Part II (基礎邏輯設計)

7. Given the Boolean function $F(X, Y, Z) = \overline{X} + X(X + \overline{Y})(Y + \overline{Z})$

    (a) (5 points) Write out the **truth table** of the Boolean function.

    (b) (5 points) Draw the **logic diagram** of the Boolean function by using AND gates, OR gates, and NOT gates. The diagram should correspond exactly to the equation. Assume that the complments of the inputs are not available.

8. (10 points) Given the Boolean function $F(A, B, C, D) = \Sigma m(0,1,2,4,5,7,10,11,15)$, find the **minimal sum-of-products** expression of the function by using **Karnaugh map**.

9. (10 points) A **n-to-2^n-line decoder with enable control** has **n** inputs, 2^n outputs, and an enable control **EN**. When **EN** = 0, the operation of the decoder is disable by setting all the outputs of the decoder to 0. When **EN** = 1, the operation of the decoder is enable. Please design a **3-to-8-line decoder with enable control** by using **three 2-to-4-line decoders with enable control**. In your answer, please draw out the **block diagram** of the 3-to-8-line decoder by using the following schematic diagram representing the 2-to-4-line decoders with enable control.
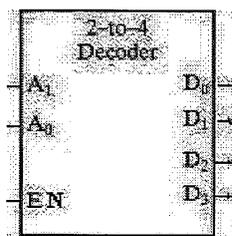
10. A sequential circuit has two flip-flops A and B, one input X and one output Y. The state table of the circuit is given below.

Present State A B	Input X	Next State A B	Output Y
0 0	0	0 1	1
0 0	1	0 0	1
0 1	0	0 1	0
0 1	1	1 0	0
1 0	0	1 1	0
1 0	1	1 0	0
1 1	0	1 1	0
1 1	1	1 1	0

Design the circuit with **D-type** flip flops. In your answer,

(a) (6 points) derive the output function and the input equations of each flip flops;

(b) (4 points) draw the logic diagram of the circuit.

11. (10 points) A **3-bit shift register** is to be operated according to the following function table using a control selection input **S**.

S	Register Operation
0	Left shift one bit
1	Right shift one bit

Design the shift register by using **D-type** flip flops. Please draw out the logic diagram of your design.

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