# O-O Programming & Data Structure Lab. 7

## 7.1 Standard Template Library (STL) vector and algorithm for class Time and class Date

(1) class Time /\* Time.h \*/ #ifndef TIME H #define TIME H #include <iostream> using namespace std; class Time friend ostream& operator<<(ostream&, const Time&); public: Time() { hour = 0; min = 0; sec = 0; } // default constructor Time(int h, int m, int s); int elasedSec() const; Time getTime() const { return Time(hour, min, sec); } bool operator<(const Time&) const; bool operator<=(const Time&) const; bool operator>(const Time&) const; bool operator>=(const Time&) const; bool operator==(const Time&) const; private: bool isValidTime(int, int, int); int hour; int min; int sec; }: #endif

#### (2) class Date

// implement member functions here !!

```
/* Date.h */
#ifndef DATE H
#define DATE H
#include <iostream>
using namespace std;
#define WEEKDAY AD01Jan01 MON // the weekday of AD Jan 1.
#define DAYS_PER_WEEK 7
class Date
     friend ostream& operator<<(ostream&, const Date&);
public:
     Date(); // default constructor
     Date(int y, int m, int d); // constructor
     ~Date(); // destructor
     int getWeekDay();
     int getElapsedDaysFromAD010101() const; // get elapsed days from AD 1. 1. 1.
     int getElapsedDaysFromAD010101(Date) const;
     bool operator<(const Date&) const;
     bool operator <= (const Date &) const;
     bool operator>(const Date&) const;
     bool operator>=(const Date&) const;
     bool operator==(const Date&) const;
private:
     bool isValidDate(int y, int m, int d);
     int year;
     int month:
     int day;
bool isLeapYear(int y); // check whether the given year y is leap year
int getYearDay(int year, int month, int day);
#endif
```

(3) class VectorHandler

```
/* VectorHandler*/
#ifndef VECTOR_HANDLER_H
#define VECTOR HANDLER H
#include <vector>
#include <algorithm>
template<typename T>
void printVector(vector<T>& v)
     string typeName = typeid(T).name();
     cout << "Vector size(" << v.size() << "), elements : \n";</pre>
     typename vector<T>::iterator p;
     for (p = v.begin(); p != v.end(); p++)
           cout << *p << " ";
           if ((typeName == "class Date") || (typeName == "class Time"))
                continue:
           else
                cout << endl;
     cout << endl;
#endif
```

(4) main() with STL vector and algorithm

```
/** main - T Array<Student, K> */
#include <iostream>
#include <conio.h> # for _getch()
#include <fstream>
#include <string>
#include <vector>
#include <algorithm>
#include "VectorHandler.h"
using namespace std;
#define NUM_TIMES 10
#define NUM_DATES 10
#define NUM_STUDENTS 10
void main()
{
     Time times[NUM TIMES] =
     {
           Time(3, 0, 30), Time(7, 30, 0), Time(2, 0, 50), Time(5, 30, 0), Time(1, 10, 0),
           Time(9, 20, 10), Time(1, 20, 15), Time(10, 0, 0), Time(11, 15, 10), Time(2, 0, 5)
     };
     vector<Time> v times(times, times+ NUM TIMES);
     cout << "Initial v times : " << endl;
     printVector(v times);
     sort(v times.begin(), v times.end());
     cout << "After sort(): " << endl;
     printVector(v times);
     Date dates[10] =
     {
           Date(2003, 4, 5), Date(2002, 7, 15), Date(2001, 5, 1), Date(2001, 3, 10), Date(2000, 5, 21),
           Date(2000, 3, 1), Date(1999, 12, 25), Date(1998, 10, 9), Date(1997, 6, 10), Date(1996, 1, 1)
     vector<Date> v dates(dates, dates + NUM DATES);
     cout << "Initial v dates:" << endl;
     printVector(v dates);
     sort(v_dates.begin(), v_dates.end());
     cout << "After sort(): " << endl;
     printVector(v dates);
     cout << "Hit any key to continue .... ";
      getch();
     cout << endl:
}
```

#### (5) 실행결과

```
| Initial v_times : | Vector size(10), elements : | (3: 0:30) (7:30: 0) (2: 0:50) (5:30: 0) (1:10: 0) (9:20:10) (1:20:15) (10: 0: 0) (11:15:10) (2: 0: 5) | After sort() : | Vector size(10), elements : | (1:10: 0) (1:20:15) (2: 0: 5) (2: 0:50) (3: 0:30) (5:30: 0) (7:30: 0) (9:20:10) (10: 0: 0) (11:15:10) | Initial v_dates : | Vector size(10), elements : | (2003. 4. 5) (2002. 7.15) (2001. 5. 1) (2001. 3.10) (2000. 5.21) (2000. 3. 1) (1999.12.25) (1998.10. 9) (1997. 6.10) (1996. 1. 1) | After sort() : | Vector size(10), elements : | (1996. 1. 1) (1997. 6.10) (1998.10. 9) (1999.12.25) (2000. 3. 1) (2000. 5.21) (2001. 3.10) (2001. 5. 1) (2002. 7.15) (2003. 4. 5) | Hit any Key to continue ....
```

# 7.2 STL vector and algorithm for class Student that inherits class Person

#### (1) class Person

```
/* Person.h */
#ifndef PERSON H
#define PERSON H
#include <iostream>
#include <string>
#include "Date.h"
#include "Time.h"
class Person
     friend ostream& operator<< (ostream& fout, const Person& p)
           fout << " Person [name: " << p.name << "]";
           return fout;
public:
     Person() { name = "nobody"; }
     Person(string n) { name = n; }
     void setName(string n) { name = n; }
     string getName() { return name; }
     void setDoB(Date dob) { dateOfBirth = dob; }
     const Date getDoB() const { return dateOfBirth; }
     void setArrivalTime(Time t) { arrivalTime = t; }
     const Time getArrivalTime() const { return arrivalTime; }
protected:
     string name;
     Date dateOfBirth: // date of birth
     Time arrivalTime:
};
#endif
```

#### (2) class Student

```
/* Student.h */
#ifndef STUDENT H
#define STUDENT H
#include "Person.h"
#include "Date.h"
#include "Time.h"
class Student: public Person
     friend ostream & operator<< (ostream &, Student &);
public:
     Student(); // default constructor
     Student(int s id, string n, Date dob, Time avt, double gpa);
     void getKey(string keyName, void* pKey);
     bool operator<(const Student&) const;
     bool operator<=(const Student&) const;
     bool operator>(const Student&) const;
     bool operator>=(const Student&) const;
     bool operator==(const Student&) const;
```

```
private:
      int st id;
      double gpa;
};
#endif
```

(3) main() with STL vector and algorithm for class Student

```
/** main – STL vector and algorithm for class Student */
#include <iostream>
#include <conio.h> # for _getch()
#include <fstream>
#include <string>
#include <vector>
#include <algorithm>
#include "VectorHandler.h"
using namespace std;
#define NUM_TIMES 10
#define NUM_DATES 10
#define NUM_STUDENTS 10
void main()
{
     Student students[NUM_STUDENTS] =
           Student(5234, string("Kim, G-M"), Date(2002, 7, 15), Time(3, 0, 30), 3.57),
           Student(1999, string("Yoon, S-M"), Date(1999, 12, 25), Time(7, 30, 0), 4.37),
           Student(4141, string("Byun, S-S"), Date(2001, 3, 10), Time(2, 0, 50), 2.72),
           Student(2167, string("Lee, K-M"), Date(1998, 10, 9), Time(5, 30, 0), 3.35),
           Student(3890, string("Hong, G-M"), Date(2000, 3, 1), Time(1, 10, 0), 3.89),
           Student(6543, string("Jang, S-M"), Date(2000, 5, 21), Time(9, 20, 10), 4.42),
           Student(7080, string("Park, S-T"), Date(2001, 5, 1), Time(1, 20, 15), 4.12),
           Student(9564, string("Choi, Y-H"), Date(1997, 6, 10), Time(10, 0, 0), 3.85),
           Student(1000, string("Shin, D-J"), Date(2003, 4, 5), Time(11, 15, 10), 3.21),
           Student(8812, string("Ahn, S-B"), Date(1997, 1, 1), Time(2, 0, 5), 4.45),
     };
     vector<Student> v_students(students, students + NUM_DATES);
     cout << "Initial v_students :" << endl;
     printVector(v_students);
     sort(v_students.begin(), v_students.end());
     cout << "\mstudents after sorting by st id:" << endl;
     printVector(v students);
     cout << "Hit any key to continue .... ";
     _getch();
     cout << endl;
}
```

#### (4) 실행결과

```
Initial
Vector s
Student
Student
Student
Student
                                                    v_studen
ize(10),
[ st_id:
                                                                                                     ts: elements: 5234, name: 1999, name: 4141, name: 2167, name: 3890, name: 6543, name: 7080, name: 9564, name: 1000, name: 8812, name:
                                                                                                                                                                                                                       G-M, gpa:
S-M, gpa:
S-S, gpa:
K-M, gpa:
G-M, gpa:
S-T, gpa:
Y-H, gpa:
D-J, gpa:
S-B, gpa:
                                                                                                                                                                                     Kim,
Yoon,
Byun,
                                                                                                                                                                                                                                                                                                                                 date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            arrival
arrival
arrival
arrival
arrival
arrival
arrival
arrival
                                                                                                                                                                                                                                                                                     3.57
4.37
2.72
3.35
3.89
4.42
4.12
3.85
3.21
4.45
                                                                                                                                                                                                                                                                                                                                                                                                                          (2002, 7.15), (1999.12.25), (2001, 3.10), (1998.10.9), (2000, 3.1), (2000, 5.21), (2001, 5.1), (1997, 6.10), (1997, 1.1), (1997, 1.1),
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           : 0:30)
:30: 0)
: 0:50)
:30: 0)
:10: 0)
:20:10)
:20:15)
: 0: 0)
:15:10)
                                                                                                                                                                                     Lee,
Hong,
                                                                                                                                                                                                                                                                                                                               date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
     Student
   Student
Student
Student
                                                                                                                                                                                     Jang,
Park,
Choi,
Shin,
  Student
Student
                                                [ st_id:
students after so
Vector size(10),
Student [ st_id:
                                                                                           sorting by st_id:
), elements:
d: 1000, name: Shi
d: 1999, name: Yoo
d: 2167, name: Lee
d: 3890, name: Hon
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    (11:15:10)
(7:30: 0)
(5:30: 0)
(1:10: 0)
(2: 0:50)
(3: 0:30)
(9:20:10)]
(1:20:15)]
(2: 0: 5)]
(10: 0: 0)]
                                                                                                                                              ts:
name: Shin, D-J, gpa: 3.21
name: Yoon, S-M, gpa: 4.37
name: Lee, K-M, gpa: 3.35
name: Hong, G-M, gpa: 3.89
name: Byun, S-S, gpa: 2.72
name: Kim, G-M, gpa: 3.57
name: Jang, S-M, gpa: 3.57
name: Park, S-T, gpa: 4.12
name: Ahn, S-B, gpa: 4.12
name: Choi, Y-H, gpa: 3.85
                                                                                                                                                                                                                                                                                                                              date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
date_of_birth:
                                                                                                                                                                                                                                                                                                                                                                                                                          (2003. 4. 5),
(1999.12.25),
(1998.10. 9),
(2000. 3. 1),
(2001. 3.10),
(2002. 7.15),
(2000. 5.21),
(2000. 5. 21),
(2001. 5. 1),
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            arrival
arrival
arrival
arrival
arrival
arrival
                                                                                                           5890,
4141,
5234,
6543,
7080,
8812,
 Student [ st_id:
Student [ st_id:
                                                                                                                                                                                                                                                                                                                                                                                                                           (1997. 1. 1), arrival: (1997. 6.10), arrival:
                                                                                                             9564.
                                                                                                                                                                                                                                                                                                                               date_of_birth:
   Hit any key to continue
```

## 7.3 Generic Template Class T\_Array for class Student

(1) class T Array

```
/* Template class T Array.h */
#ifndef T_Array_H
#define T_Array_H
#include <iostream>
#include <iomanip>
#include "Date.h"
#include "Time.h"
using namespace std;
enum SortingOrder { INCREASING, DECREASING };
template<typename T, typename K>
class T_Array
{
public:
   T Array(int n, string nm); // constructor
   ~T Array(); // destructor
   int size() { return num_elements; }
   bool empty() { return num_elements == 0; }
   string getName() { return name; }
   void insert(int i, T element);
   int sequential_search(K search_key); // search and return the index; -1 if not found
   int binary_search(K search_key); // search and return the index; -1 if not found
   void selection_sort(string keyName, SortingOrder sortOrder);
   void print(int elements_per_line);
   bool isValidIndex(int i);
   T& operator[](int index) { return t array[index]; }
private:
   T *t array;
   int num elements;
   int capacity;
   string name;
};
template<typename T, typename K>
T Array<T, K>::T Array(int new capacity, string nm) // constructor
{
   // . . . .
}
template<typename T, typename K>
T_Array<T, K>::~T_Array() // destructor
{
   // . . . .
}
template<tvpename T. tvpename K>
bool T Array<T, K>::isValidIndex(int index)
   // . . . .
}
template<typename T, typename K>
void T_Array<T, K>::insert(int i, T new_element)
{
   // . . . .
}
template<typename T, typename K>
int T_Array<T, K>::sequential_search(K search_key)
{
   // . . . .
}
```

```
template<typename T, typename K>
int T_Array<T, K>::binary_search(K search_key)
    // . . . .
}
template<typename T, typename K>
void T Array<T, K>::selection_sort(string keyName, SortingOrder sortOrder)
   // . . . .
}
template<typename T, typename K>
void T Array<T, K>::print(int elements per line)
   int count = 0:
   while (count < num elements)
         for (int i = 0; i < elements per line; <math>i++)
                  cout << t array[count] << " ";
                  count++:
                  if (count % elements per line == 0)
                           cout << endl;
         }
   cout << endl;
#endif
```

(2) Template Class T\_Array의 generic algorithm 사용을 위한 class Student의 기능 추가

```
void Student::getKey(string keyName, void* pKey)
{
    if (keyName == "ST_ID")
        *(int *)pKey = this->st_id;
    else if (keyName == "ST_NAME")
        *(string *)pKey = this->name;
    else if (keyName == "GPA")
        *(double *)pKey = this->gpa;
    else if (keyName == "ARRIVAL_TIME")
        *(Time *)pKey = this->arrivalTime;
    else if (keyName == "BIRTH_DATE")
        *(Date *)pKey = this->dateOfBirth;
    else
        pKey = NULL;
}
```

(3) main()

```
/** main - T_Array<Student, K> (1) */
#include <iostream>
#include <conio.h> # for getch()
#include <fstream>
#include <string>
#include <vector>
#include <algorithm>
#include "T_Array.h"
#include "Student.h"
#include "VectorHandler.h"
using namespace std;
#define STEP_1
#define STEP_2
#define STEP_3
#define STEP 4
#define NUM TIMES 10
```

```
#define NUM DATES 10
#define NUM STUDENTS 10
void main()
     Student students[NUM_STUDENTS] =
           Student(5234, string("Kim, G-M"), Date(2002, 7, 15), Time(3, 0, 30), 3.57),
           Student(1999, string("Yoon, S-M"), Date(1999, 12, 25), Time(7, 30, 0), 4.37), Student(4141, string("Byun, S-S"), Date(2001, 3, 10), Time(2, 0, 50), 2.72),
           Student(2167, string("Lee, K-M"), Date(1998, 10, 9), Time(5, 30, 0), 3.35),
           Student(3890, string("Hong, G-M"), Date(2000, 3, 1), Time(1, 10, 0), 3.89),
           Student(6543, string("Jang, S-M"), Date(2000, 5, 21), Time(9, 20, 10), 4.42),
           Student(7080, string("Park, S-T"), Date(2001, 5, 1), Time(1, 20, 15), 4.12),
           Student(9564, string("Choi, Y-H"), Date(1997, 6, 10), Time(10, 0, 0), 3.85),
           Student(1000, string("Shin, D-J"), Date(2003, 4, 5), Time(11, 15, 10), 3.21),
           Student(8812, string("Ahn, S-B"), Date(1997, 1, 1), Time(2, 0, 5), 4.45),
     };
#ifdef STEP 3
     /* Step 3 - Testing template array class T Array<T, K> */
     Student* pSt:
     T Array<Student, int> stArray keyID(NUM STUDENTS, "T Array<Student, keyST ID>");
     for (int i = 0; i < NUM STUDENTS; i++)
           stArray keyID.insert(i, students[i]);
     cout << "T_Array<Student_keyID> at initialization : " << endl;</pre>
     stArray keyID.print(1);
     stArray keyID.selection_sort(string("ST_ID"), INCREASING);
     cout << "\nT Array<Student_keyID> after sorting (increasing order) by ST_ID: " << endl;
     stArray keyID.print(1);
     T_Array<Student, double> stArray_keyGPA(NUM_STUDENTS, "T_Array<Student, keyGPA>");
     for (int i = 0; i < NUM_STUDENTS; i++)
     {
           stArray keyGPA.insert(i, students[i]);
     stArray keyGPA.selection sort(string("GPA"), DECREASING);
     cout << "\nT_Array<Student, keyGPA> after sorting (decreasing order) by GPA: " << endl;
     stArray keyGPA.print(1);
     cout << "Hit any key to continue .... ";
     _getch();
     cout << endl:
#endif
#ifdef STEP 4
     T_Array<Student, string> stArray_keyName(NUM_STUDENTS, "T_Array<Student,
             keyName>");
     for (int i = 0; i < NUM_STUDENTS; i++)
           stArray keyName.insert(i, students[i]);
     stArray_keyName.selection_sort(string("ST_NAME"), INCREASING);
     cout << "\nT Array<Student keyName> after sorting (increasing order) by name : " << endl;
     stArray keyName.print(1);
     T_Array<Student, Date> stArray_keyDoB(NUM_STUDENTS,
             "Array of Students, date of birth as key");
     for (int i = 0; i < NUM STUDENTS; i++)
     {
           stArray keyDoB.insert(i, students[i]);
     stArray keyDoB.selection sort(string("BIRTH DATE"), INCREASING);
     cout << "\nstArray keyDoB after sorting (increasing order) by date of birth: " << endl;
     stArray keyDoB.print(1);
     T_Array<Student, Time> stArray_keyTime(NUM_STUDENTS,
              "Array of Students, arrival time as key");
     for (int i = 0; i < NUM_STUDENTS; i++)
```

```
{
    stArray_keyTime.insert(i, students[i]);
}
stArray_keyTime.selection_sort(string("ARRIVAL_TIME"), INCREASING);
cout << "\nstArray_keyArrTm after sorting (increasing order) by arrival time : " << endl;
stArray_keyTime.print(1);
#endif
}</pre>
```

# (4) 실행 결과 (step\_3)

```
at initialization
, name: Kim, G-M,
, name: Yoon, S-M,
, name: Byun, S-S,
, name: Lee, K-M,
    _Array<Student_keyID> :
tudent [ st_id: 5234,
tudent [ st_id: 1999,
                                                                                                                        3.57
4.37
2.72
3.35
                                                                                                                                                                                  (2002. 7.15),
(1999.12.25),
(2001. 3.10),
(1998.10. 9),
                                                                                                                                                                                                                                                   3: 0::
7:30:
2: 0::
5:30:
   tudent
                                                                                                                                           date_of_birth:
date_of_birth:
Student
                                                                                                           apa:
                                                                                                                                                                                                                      arrival:
                                                                                                                                                                                                                                                        0:50)
30: 0)
10: 0)
                                               4141,
2167,
                                                                                                                                           date_of_birth:
                          st_id:
                                                                                                                                           date_of_birth:
                                                                                                                                                                                                                      arrival:
 Student
                                                                                                           gpa:
                                                                                             G-M,
S-M,
S-T,
Y-H,
D-J,
S-B,
                                                                                                                        3.89
4.42
4.12
3.85
3.21
4.45
Student
Student
                          st_id:
st_id:
                                               3890
                                                              name:
                                                                              Hong,
                                                                                                           gpa:
                                                                                                                                           date_of_birth:
                                                                                                                                                                                   (2000)
                                                                                                                                                                                                                      arrival:
                                                                                                                                                                                  (2000)
(2001)
(1997)
(2003)
                                               6543,
7080.
                                                                             Jang,
Park,
Choi,
Shin,
                                                                                                                                           date_of_birth:
                                                                                                                                                                                                        .21),
                                                                                                                                                                                                                      arrival
                                                              name:
                                                                                                           gpa:
                         st_id:
st_id:
                                                                                                          gpa:
gpa:
                                                                                                                                                                                                                      arrival:
arrival:
Student
                                                              name:
                                                                                                                                           date of birth:
                                                                                                                                                                                                                                                   1:20:15)
   tudent
                                                              name:
                                                                                                                                           date_of_birth:
                         st_id:
st_id:
 Student
                                                10000.
                                                              name:
                                                                                                           apa:
                                                                                                                                           date of birth:
                                                                                                                                                                                                                      arrival:
    _Array<Student_keyID> after sorting (increasing order) by ST_ID
tudent [ st_id: 1000, name: Shin, D-J, gpa: 3.21 , date_of_bir:
tudent [ st_id: 1999, name: Yoon, S-M, gpa: 4.37 , date_of_bir:
tudent [ st_id: 2167, name: Lee, K-M, gpa: 3.35 , date_of_bir:
                                                                                                                                                                                  (2003. 4. 5),
(1999.12.25),
(1998.10. 9),
(2000. 3. 1),
(2001. 3.10),
(2002. 7.15),
(2000. 5.21),
(2001. 5. 1),
(1997. 1. 1)
Student
Student
                                                                                                                                          date_of_birth:
date_of_birth:
                                                                                                                                                                                                                      arrival:
                                                                                                                                                                                                                                                  7:30: 0)

5:30: 0)

1:10: 0)

2: 0:50)

3: 0:30)

9:20:10)
                                                                                                                                                                                                                      arrival
                                                                                                                      4.37
3.35
3.89
2.72
3.57
4.42
4.12
4.45
3.85
                          st_id:
st_id:
Student
                                                                                                                                           date of birth:
                                                                                                                                                                                                                      arrival:
                                                                                             K-M, gpa:
G-M, gpa:
S-S, gpa:
G-M, gpa:
S-M, gpa:
S-T, gpa:
S-B, gpa:
Y-H, gpa:
                                               3890,
4141,
  Student
                                                                              Hong,
                                                                                                                                           date_of_birth:
                                                              name:
                                                                              Byun.
                                                                                                                                                                                                                      arrival:
 Student
                          st id:
                                                              name:
                                                                                                                                           date of birth:
                         st_id:
st_id:
st_id:
st_id:
                                              5234,
6543,
7080,
8812,
                                                                             Kim,
Kim,
Jang,
Park,
Ahn,
Choi,
                                                                                                                                                                                 (2001.
(2002.
(2000.
(2001.
(1997.
(1997.
                                                              name:
                                                                                                                                          date_of_birth:
date_of_birth:
                                                                                                                                                                                                                                             ( 9:20:10)]
( 9:20:15)]
( 1:20:15)]
( 2: 0: 5)]
(10: 0: 0)]
Student
                                                              name:
                                                                                                                                                                                                                      arrival:
                                                              name:
name:
                                                                                                                                          date_of_birth:
date_of_birth:
Student
                                                                                                                                                                                                                      arrival
Student [ st_id:
                                               9564
                                                                                                                                                                                                   6.10)
                                                              name:
                                                                                                                                           date of birth:
                                                                                                                                                                                                                      arrival:
                                                                            er sorting (decreasing Ahn, S-B, gpa: 4.45 Jang, S-M, gpa: 4.42 Yoon, S-M, gpa: 4.37 Park, S-T, gpa: 3.89 Choi, Y-H, gpa: 3.57 Kim, G-M, gpa: 3.57 Shin, D-J, gpa: 3.21 Byun, S-S, gpa: 2.72
                                            keyGPA> after
8812, name: A
6543, name: S
                                                                                                                                    order) by GPA:
, date_of_birth;
, date_of_birth;
, date_of_birth;
Student
Student
Student
                                                                                                                                                                                                                                                   2: 0: 5)
9:20:10)
7:30: 0)
                         st_id:
st_id:
st_id:
                                                                                                                                                                                 (1997. 1. 1), arrival: (2000. 5.21), arrival: (1999.12.25), arrival: (2001. 5. 1), arrival: (2000. 3. 1), arrival: (1997. 6.10), arrival: (2002. 7.15), arrival: (1998.10. 9), arrival: (2003. 4. 5), arrival: (2001. 3.10), arrival:
                                                              name:
                                                                                                                                                                                                                                                   7:30: 0)
1:20:15)
                                                              name:
Student
                          st_id:
st_id:
                                               7080
                                                              name:
                                                                                                                                           date_of_birth:
date_of_birth:
                                                                                                                                                                                                                                                                  (0)
(0)
                                                              name:
Student [ st_id:
                                                                                                                                                                                                                                              (10: 0:
                                               9564.
                                                              name:
                                                                                                                                           date of birth:
                                                                                                                                                                                                                                             (3: 0:30)
(5:30: 0)
(11:15:10)
(2: 0:50)
                                               5234,
2167,
                                                                                                                                          date_of_birth:
date_of_birth:
                                                              name:
                                                                                                                                     , date_of_birth:
, date_of_birth:
, date_of_birth:
                                                              name:
                                                              name:
                                               4141,
                                                              name:
Hit any key to continue
```

# (5) 실행 결과 (step\_4)

```
_Array<Student_keyName> after sorting (increasing order) by name:
tudent [ st_id: 8812, name: Ahn, S-B, gpa: 4.45, date_of_birth:
tudent [ st_id: 4141, name: Byun, S-S, gpa: 2.72, date_of_birth:
tudent [ st_id: 9564, name: Choi, Y-H, gpa: 3.85, date_of_birth:
                                                                                                                                                                                                                                         ( 2:
( 2:
(10:
Student
                                                                                                                                                                              (1997. 1. 1),
(2001. 3.10),
(1997. 6.10),
(2000. 3. 1),
(2000. 5.21),
(2002. 7.15),
(1998.10. 9),
(2001. 5. 1),
(2003. 4. 5),
(1999.12.25)
                                                                                                                                                                                                                                            2: 0:50)
10: 0: 0)
1:10: 0)
9:20:10)
                                                                                                                                                                                                                  arrival:
Student
                                                                                                                                                                                                                  arrival:
                                                                                                                   3.85
3.89
4.42
3.57
3.35
4.12
3.21
4.37
                                                                                           G-M,
S-M,
                                              3890,
                                                            name:
                                                                            Hong,
                                                                                                        gpa:
                                                                                                                                       date_of_birth
                                                                                                                                                                                                                  arriva
Student
                         st id:
                                              6543.
                                                            name:
                                                                             Jang,
                                                                                                        apa:
                                                                                                                                       date of birth
                                                                                                                                                                                                                  arrival:
                                             5234,
2167,
7080,
1000,
                                                                                                                                                                                                                                       ( 9: 20: 10)
( 3: 0: 30)
( 5: 30: 0)
( 1: 20: 15)
( 11: 15: 10)
( 7: 30: 0)
                                                                                           G-M,
K-M,
S-T,
D-J,
S-M,
Student
                                                                            Kim,
                                                             name:
                                                                                                        gpa:
                        st_id:
st_id:
st_id:
                                                                           Lee,
Park,
Shin,
Student
                                                            name:
                                                                                                        gpa:
                                                                                                                                       date of birth
                                                                                                                                                                                                                  arrival:
                                                                                                                                       date_of_birth
date_of_birth
                                                                                                                                                                                                                 arrival:
arrival:
                                                            name:
                                                                                                        gpa:
                                                            name:
                                                                                                        gpa:
                                              1999.
                                                            name:
                                                                                                                                                                              (1999.12.25),
                                                                                          asing order) by date of birth
S-B, gpa: 4.45, date_of_birt
Y-H, gpa: 3.85, date_of_birt
K-M, gpa: 3.35, date_of_birt
S-M, gpa: 3.36
stArray_keyDoB after sorting (increasing order)
Student [ st_id: 8812, name: Ahn, S-B, gpa: 4
Student [ st_id: 9564, name: Choi, Y-H, gpa: 3
Student [ st_id: 2167, name: Lee, K-M, gpa: 3
                                                                                                                                                                                                                 arrival:
arrival:
arrival:
arrival:
                                                                                                                                       date_of_birth:
date_of_birth:
                                                                                                                                                                              (1997)
(1997)
                                                                                                                                                                                (1997, 1, 1), (1997, 6,10), (1998, 10, 9), (1998, 12, 25), (2000, 3, 1), (2000, 5, 21), (2001, 5, 1), (2001, 5, 1), (2002, 7,15), (2003, 4, 5),
                                                                                                                                                                                                                                                            0) 0) 0)
                                                                                                                                                                                                                                         (10: 0:
(5:30:
(7:30:
                                                                           Lee,
Yoon,
                                                                                                                                       date_of_birth:
date_of_birth:
                                                             name:
 Student
                                                            name:
                                                                                                                   4.37
3.89
4.42
2.72
4.12
3.57
3.21
                                                                                           G-M,
S-M,
S-S,
S-T,
G-M,
D-J,
Student
                        st_id:
st_id:
                                              3890
                                                            name:
name:
                                                                           Hong,
Jang,
                                                                                                        gpa:
                                                                                                                                       date of birth
                                                                                                                                                                               (2000)
                                                                                                                                                                                                                  arrival:
arrival:
                                                                                                                                                                                                                                              1:10:
                                                                                                                                                                                                                                             9:20:10)
2: 0:50)
1:20:15)
                                             6543,
4141,
  Student
                                                                                                                                       date_of_birth
                                                                           Byun,
Park,
Kim,
Shin,
                                                                                                                                                                              (2001.
(2001.
(2002.
                        st_id:
st_id:
                                              4141, name:
7080, name:
                                                                                                                                       date_of_birth
date_of_birth
                                                                                                                                                                                                                 arrival:
arrival:
Student
                                                                                                        gpa:
Student [ st_id:
Student [ st_id:
Student [ st_id:
Student [ st_id:
                                                                                                       gpa:
                                              5234
                                                                                                                                                                                                                 arrival: (3:0:30)]
arrival: (11:15:10)]
                                                            name:
                                                                                                       gpa:
                                                                                                                                       date of birth
                                                            name:
                                           after sorting (increasing order)
stArray_keyArrTm
Student [ st_id:
                                                                           g (increasing order) by Hong, G-M, gpa: 3.89, Park, S-T, gpa: 4.12, Ahn, S-B, gpa: 4.45, Byun, S-S, gpa: 2.72, Kim, G-M, gpa: 3.57, Lee, K-M, gpa: 3.35, Yoon, S-M, gpa: 4.37, Jang, S-M, gpa: 4.42, Choi, Y-H, gpa: 3.85, Shin, D-J, gpa: 3.21,
                                                                                                                               by arrival time
                                                                                                                                                                                                                                            1:10: 0)

1:20:15)

2: 0: 5)

2: 0:50)

3: 0:30)

5:30: 0)

7:30: 0)

9:20:10)
                                                                                                                                                                                               3.
5.
1.
                                             3890,
7080,
                                                                                                                                       date_of_birth:
date_of_birth:
                                                                                                                                                                              (2000.
(2001.
                                                                                                                                                                                                                  arrival:
arrival:
                                                                                                                                                                             J. 1
J. 3.10),
2002, 7.15),
(1998.10, 9),
(1999.12.25), &
2000, 5.21), a
1997. 6.10),
'003. 4. 5
Student
                                                            name:
                                             8812,
4141,
                                                                                                                                       date_of_birth
date_of_birth
Student
                                                             name:
                                                                                                                                                                                                                  arrival:
Student
                         st id:
                                                                                                                                                                                                                  arrival:
                                                            name:
Student
Student
                                             5234,
2167,
                                                                                                                                       date_of_birth
date_of_birth
                                                             name:
                        st_id:
                                                                                                                                                                                                                  arrival
                                                            name:
                        st_id:
st_id:
                                              1999
                                                                                                                                       date_of_birth
date_of_birth
                                                                                                                                                                                                                 arrival:
arrival:
Student
                                                             name:
  tudent
                                                            name:
                                                            name:
name:
                                                                                                                                       date_of_birth:
date_of_birth:
                                                                                                                                                                                                                  arrival: (10: 0: 0)
arrival: (11:15:10)
Student
```

### 7.5 Oral Test

- (1) 클래스 템플릿이 무엇이며, 클래스 템플릿을 사용하는 장점과 단점에 대하여 예를 들어 설명하라.
- (2) STL (Standard Template Library)는 무엇이며, 어떤 기능 (자료구조 또는 알고리즘)이 제공되는가에 대하여 표를 만들어 설명하라. (Keypoints: container, algorithm, iterator)
- (3) STL vector, STL list, STL deque 이 제공하는 주요 멤버함수 들에 대하여 설명하라.
- (4) 알고리즘 추상화 (algorithm abstraction)는 무엇이며, 알고리즘 추상화를 어떻게 구현하는가를 대하여 퀵 정렬을 예로 들어 설명하라. 이 일반화된 알고리즘이 다수의 속성을 가지는 클래스 배열에 사용될 수 있게 하고, 알고리즘에 사용되는 기준 키의 이름 (keyName)이 알고리즘 호출에 전달되는 구조를 사용할 것.