Week 9

Muhao Chen

muhaochen@ucla.edu

http://yellowstone.cs.ucla.edu/~muhao/

Outline

- Class
- Final Practice

Class

```
class vending_machine {
   public:
      int get_num() const; //accessor
      double get_price() const; //accessor
      void set_num(const int& num);//modifier
   private:
      int num;
      double price;
};
```

```
class human {
   public:
      bool buy_one(const vending_machine &vm);
   private:
      int num_items;
      double cash;
};
```

Implement simple member functions

Accessor:

```
int vending_machine::get_num() const {
   return num;
};
```

Or we can say: (this is a pointer that points to the object itself).

```
int vending_machine::get_num() const {
   return this -> num;
};
```

Modifier:

```
void vending_machine::set_num(const int& num) {
   this -> num = num;
};
```

Constructors: functions to specify the behavior of object initiation

Default constructor (no parameter):

Function name is the same as the class name. No return type specification.

```
vending_machine::vending_machine() {
    num=10;
    price=1.75;
};
…
vending_machine vm; //vm is a vending machine that sells 10 items at $1.75 each
```

Constructor with parameters:

```
vending_machine::vending_machine(const int& num, const double & price) {
    this->num=num;
    this->price=price;
};
…
vending_machine vm(30, 2.0); //vm sells 20 items at $2 each
```

Constructors: functions to specify the behavior of object initiation

If we do not specify any constructors for a class, an **empty constructor** will be provided by default. But it will not if we have specified a constructor.

```
class human {
   public:
      bool buy_one(const vending_machine &vm);
   private:
      int num_items;
      double cash;
};

human::human(const int& num, const double & cash) {
    this->num_items=num;
    this->cash=cash;
};
```

Can we do this?

human hm;

No. We have to do:

human hm(0, 80.0);

Because default constructor is not available.

Constructors: functions to specify the behavior of object initiation

Multiple constructors with different combinations of parameter types.

```
class human {
   public:
      bool buy_one(const vending_machine &vm);
   private:
      int num_items;
      double cash;
};
human::human(const int& num, const double & cash) {
    this->num_items=num;  this->cash=cash;
};
human::human(const double & cash) {
    this->num_items=0;  this->cash=cash;
};
human::human() {
    this->num_items=0;  this->cash=60.0;
};
```

Caution: private member variables/functions

A private member variable/function can only be seen by the code of this class.

```
class vending_machine {
   public:
      int get_num() const; //accessor
      double get_price() const; //accessor
      void set_num(const int& num);//modifier
   private:
      int num;
      double price;
};
```

Cannot seen by a human.
Cannot seen by other functions

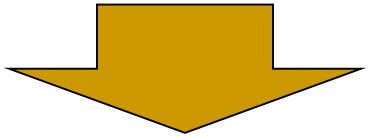
```
class human {
   public:
      bool buy_one(const vending_machine &vm);
   private:
      int num_items;
      double cash;
};
```

Cannot seen by a VM. Cannot seen by other functions (incl. main)

Caution: private member variables/functions

- To implement buy_one, can we do:

```
bool human::buy_one(const &vending_machine vm) {
    if (vm.num <= 0 || this->cash <= vm.price) return false;
    vm.num -= 1;
    this->cash -= vm.price;
    return true;
}
```



```
bool human::buy_one(vending_machine &vm) {
    if (vm.get_num() <= 0 || this->cash <= vm.get_price()) return false;
    vm.set_num(vm.get_num() - 1);
    this->cash -= vm.get_price();
    return true;
}
```

Destructor: things to do when an object is destructed

```
vending_machine::~vending_machine() {
    cout<< “A vending machine is out of order.”
};

int main() {
   vending_machine vm;
   return 0;
}
// we’ll see “A vending machine is out of order.”
```

Destructor

- A destructor is necessary when we have **dynamically allocated member variables**:

```
class vending_machines {
   public:
      vending_machines(int num) {
            vms = new vending_machine*[num];
            for (int i=0; i<num; ++i)
                  vms[i] = new vending_machine;
            this->num = num;
      }
   private:
      vending_machine **vms;
      int num;
};
```

```
vending_machines::~vending_machines() {
    for (int i=0; i<num; ++i) delete vms[i]
    delete[] vms;
}
```

Class: Things to be careful during the final (esp. coding parts)

- Do not access the private members of another class (look at page 9)
- Use the correct version of constructor (page 6)
- Release dynamic allocated items in the destructor (page 11)

Some practice for final

#1 True or False

True False	Variable names can be started with an alphabet or a digit.
True False	A string cannot be empty.
True False	A character cannot be empty.
True False	An array can have a size of 0.
True False	int m = 5.6; won't compile because types do not match.
True False	int n = 14 / 5; will create n and initialize it with the value of 2.
True False	An array index begins with 0.
True False	for (int i = 0; i <= 49; i++) will run the loop 50 times (assuming i is not modified within the loop).
True False	The C-string char s[100] can store at most 99 characters.
True False	Constant variables can be modified only in the main() function.
True False	int x = 0.0; sets x to an integer 0.
True False	int x = 0.5; sets x to an integer 0.
True False	double x = 3; sets x to a double float 3.0.

#2 Parameters

```
int func1(int &a, int m, int &b) {
    m = a; a = b; b = m;
}
int main1() {
   int x=0, y=1;
   func1(x, NULL, y);
}
```

```
int func2(int &a, int &m, int &b) {
    m = a; a = b; b = m;
}
int main2() {
   int x=0, y=1;
   func2(x, NULL, y);
}
```

```
int func3(int *a, int *m, int *b) {
    int *t = a; a = b; b = t;
}
int main3() {
   int x=0, y=1;
   func3(&x, NULL, &y);
}
```

```
int func4(int *a, int *m, int *b) {
    int t = *a; *a = *b; *b = t;
}
int main4() {
   int x=0, y=1;
   func4(&x, NULL, &y);
}
```

Which functions swap x and y?
(A) main1 (B) main2 (C) main3 (D) main4
(E) A & B & D (F) A & B & C & D (G) A & D (H) A & B & C

G main2. We cannot pass NULL to a reference type.
main3. it's actually pass-by-value.

#3 Consider the following code

```
string s1, s2("Hello");
cout << "Enter a line of input:\n";
cin >> s1;
If (s1 == s2)
    cout << "Equal\n";
else
    cout << "Not equal\n";
```

If our input on the screen is as below:
Enter a line of input:
Hello my friend! My name is Dimitri Petrenko.

What is the output?
(A) Not equal (B) Equal (C) Nothing

B. cin flow terminates a single >> with a whitespace or Enter.

#4 Assume the following variable declarations:

```
int foo = 0;
int *ptr = &foo;
```

Which of the following statements will change the value of foo to 1?
(A) *ptr++; (B) foo++; (C) (*foo)++; (D) (*ptr)++;
(E) A & B & D (F) A & D (G) B & D (H) C & D

G ++ suffix has higher precedence than *.

#5 Consider following four functions

```
void s_toLowerA(char s[]) {
    int i=0;
    while (s[i] != '\0')
        s[i++] = tolower(s[i]);
}
```

```
void s_toLowerB(char s[]) {
    int i=0;
    while (s[i] != '\0')
        s[i] = tolower(s[i++]);
}
```

```
void s_toLowerC(char s[]) {
    int i=0;
    while (s[i] != '\0')
        s[++i] = tolower(s[i]);
}
```

```
void s_toLowerD(char s[]) {
    int i=0;
    while (s[i] != '\0')  {
        s[i] = tolower(s[i]); ++i;
    }
}
```

Which of them correctly changes any C-string to its lowercase?
(A) s_toLowerA (B) s_toLowerB (C) s_toLowerC (D) s_toLowerD
(E) A & C & D (F) A & B & D (G) A & B & C & D (H) A & D

F ++ suffix has lower priority than = and parameter passing. We know that i=j++ assigns j to i before increases j. Even ++ is a part of right-hand side parameter, it still increases after assignment.

#6 Modify the age of the cat

```
class cat{
       int age;
   public:
       cat(){};
      ~cat{};
      int getAge() { return age; };
      void setAge(int n) { this -> age = n;};
};
cat kitty1 = *(new cat());
```

Which of the following changes kitty1's age into 5?
(A) kitty1.age = 5; (B) (&kitty1)->age = 5; (C) kitty1.getAge() = 5;
(D) kitty1.setAge(5); (E) C & D (F) A & B (G) A & B & C & D (H) A & B & D

D. A member without indicating "private" or "public" is by default private in a class.

getAge() only returns a read-only (immutable) value of age.

#7 Modify the age of the cat

```
struct cat{
       int age;
   public:
       cat(){};
      ~cat{};
      void getAge() { return age; };
      void setAge(int n) { this -> age = n;};
};
cat kitty1 = *(new cat());
```

Which of the following changes kitty1's age into 5?
(A) kitty1.age = 5; (B) (&kitty1)->age = 5; (C) kitty1.getAge() = 5;
(D) kitty1.setAge(5); (E) C & D (F) A & B (G) A & B & C & D (H) A & B & D

H. The only difference between struct and class in C++: if you do not indicate whether a member is public or private, then by default: **private** in **class; public** in **struct;**

Note: for C, even if age is now public, getAge() is still immutable

#8 Write delete statements to delete all dynamically allocated memory

```
int *p1 = new int[10];

int *p2[15];
for (int i = 0; i < 15; i++)
   p2[i] = new int[5];

int **p3 = new int*[5];
for (int i = 0; i < 5; i++)
  p3[i] = new int[7];

int *p4 = new int;
int *temp = p4;
p4 = p1;
p1 = temp;
```

```
delete p1;  //p1 points to the int
previously allocated to p4

for (int i = 0; i < 15; ++i)
   delete[] p2[i];  // delete each row of
p2

for (int i = 0; i < 5; ++i)
   delete[] p3[i];  // delete each row of
p3
delete[] p3;  //then delete the entire p3

delete[] p4;
```

#9 Design a data stream window

- A data stream is a system where data points come one after another. For example, we may use a data stream window to record the stock price within a period of time.
- At each time we can only use a *k*-sized “sliding window” to store *k* newest data. *k* is fixed. Each time we receive a data, we insert it into the window.
- If the window has already been filled up with *k* data points, the oldest one will expire (i.e. remove from the window) when we insert the new data.

#9 Design a data stream window

- This window supports following functionalities:

1. ***window(int k):*** constructor, create a window which can store up to *k* data.
2. ***receive(double newdata):*** we receive a new data and add into the window. If the sliding window has already got *k* data before we insert the new data, the oldest data will expire.
3. ***average():*** return the current average of all data in the window.
4. ***min(), max():*** return the current min/max data in the window.
5. ***num():*** return # of data currently stored in the window
6. ***size*()**: return the size of the window (i.e. *k*)
7. ***[i]*: access the i-th data in the window. Return the closest element if i exceeds boundary. **(Extra point)**

#9 Design a data stream window

```
//How we may want to use this window.
window win =  *(new window(3)); //the window can store 3 data
win.receive(10.0);  //received first data {10.0}
cout << win.num(); //we get 1
cout << win.size(); //we get 3
win.receive(15.0);  //received second data  {10.0, 15.0}
cout << win.average();  // we get 12.5
win.receive(20.0); //received third data {10.0, 15.0, 20.0}
win.receive(25.0); //received fourth data, the oldest data 10.0 expires
                          //{15.0, 20.0, 25.0}
cout << win.min(); // we get 15.0
win.receive(13.0); // {20.0, 25.0; 13.3}
cout << win.max(); // we get 25.0

cout << win[2]; // we get 13.3
```

Now implement the class *window*

```
class window {
     public:
          window(int n) {
               k = n; avg = num = 0;
               data = new double[n]; // a k-size double array to store k data
          }
          ~window() { delete[] data; }
          void receive(double newdata);
          double average() const;
          double max() const;
          double min() const;
           int size() const;
           int num() const;
          double &operator[ ] (int i);
     private:
          int k, num; // size, and current # of data points
          double *data;  //pointer to the beginning of the sliding window
          double avg;
}
```

receive(double newdata)

```
double window::receive(double newdata) {
    if (num < k) { // window is not filled
        data[num++] = newdata;
        avg = (avg * (num – 1) + newdata) / num; //online maintaining average
    }
    else {  //if window is filled, expire the oldest
        avg = avg – data[0] / k + newdata / k; //update avg as one expires and another is inserted
        for (int i=0; i < k -1; ++i) data[i] = data[i + 1]; //move left data[2..k-1] by 1
        data[k – 1] = newdata;  //insert new data;
    }
}
```

Others

```
double window::average() const {
    return this->avg;
}
double window::min() const {
    double m = DBL_MAX;
    for (int i=0; i<k; ++i) if (data[i] < m) m = data[i];
    return m;
}
double window::max() const {
    double m = DBL_MIN;
    for (int i=0; i<k; ++i) if (data[i] < m) m = data[i];
    return m;
}
int window::size() const {
    return k;
}
int window::num() const {
    return num;
}
```

Operator overloading

```
double& window::operator[] (int i) {
    if (i < 0) return data[0];
    if (i >= num) return data[num-1];
    return data[i];
}
```

#10 Remote control typing

Suppose we are using a remote control to type words on TV. We have a virtual keyboard on the screen (e.g. a keyboard of width 9 as below). A cursor is placed on the position of. We can either move the cursor to four directions with ^ v < >, or select the letter with * (selection will not restore the position of the cursor to A).

A B C D E F G H I
J K L M N O P Q R
S T U V W X Y Z

To type “CAT”, we need to type “>>*<<*>VV*”. Now write a function, given a word and the width of the keyboard (i.g. # of letters in each row of the keyboard), convert the word to its “remote control encoding”.

string encode(string word, int width)

Solution

- Devide the problem into three steps:

1. Given a letter, what is its position (row, col)?
2. Given a source position and a target position, what's the "remote control" encoding to move from source to target.
3. For a word, concat all the "remote control version" strings for each chars.

position of letter, movement between positions

```
void position(char letter, int width, int &row, int &col) {
    int gap = letter – ‘A’;
    row = gap / width;
    col = gap – row * width;
}
string move(int row_t, int col_t, int row_s, int col_s) {
    string res = “”;
    if (row_t > row_s) //move downwards
        for (int i=0; i<row_t – row_s; ++i)res += “v”;
    else if (row_t < row_s)  //move upwards
        for (int i=0; i<row_s – row_t; ++i)res += “^”;
    if (col_t > col_s) //move >
        for (int i=0; i<col_t – col_s; ++i)res += “>”;
    else if (col_t < col_s)  //move <
        for (int i=0; i<col_s – col_t; ++i)res += “<”;
    return res + “*”;
}
```

Encode

```
string encode(string word, int width) {
    string res="";
    int row_s, col_s, row_t, col_t;
    row_s = col_s = 0; //position of A
    for (int i=0; word[i] != '\0'; ++i) {
        position(word[i], width, row_t, col_t);
        res += move(row_t, col_t, row_s, col_s);
        row_s = row_t; //current target position is the source position for next char
        col_s = col_t;
    }
    return res;
}
```

Thank you. Best of luck.