

Struct

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1 Structures / Records

quick intro: <http://www.cplusplus.com/doc/tutorial/structures/>

Student Records

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struct - a group of data elements grouped together under one name - struct types are user-defined advanced data types - elements also called members can have different types and sizes - data structures are analogous to data records such as student records, grade records, health records, inventory, employee records, criminal records, etc. - struct is a keyword that allows us to define data structures

1.2 Headers and helper functions

- run include headers and helper function cells if Kernel crashes or is restarted

```
[4]: // headers and namespace required in this notebook demo code  
#include <iostream>  
#include <string>  
  
using namespace std;
```

1.3 defining struct types

```
struct typeName {  
    type1 member1;  
    type2 member2;  
    type3 member3;  
    .  
    .  
};
```

- do NOT initialize members in struct definition
- object(s) can be declared right after closing }

```
[2]: // struct definition
struct Product {
    int weight;
    float price;
};
```

```
[3]: struct Name_T {
    string fName;
    char MI;
    string lName;
};
```

```
[4]: struct Student_T {
    Name_T name;
    Name_T parentName;
    float tests[3];
    float hws[3];
};
```

1.4 using struct types

- declare variables/objects of struct types
- access members using member access operator (.)
- do operations permitted to the type of each member

```
[6]: // declare variables/objects of struct type
Product apple;
Product banana;
```

```
[23]: cout << sizeof(apple) << " Bytes (B) \n";
cout << sizeof(Name_T) << " B\n";
cout << sizeof(Student_T) << " B \n";
```

8 Bytes (B)

56 B

160 B

```
[12]: apple.weight = 10;
apple.price = 3.5;

banana.weight = 5;
banana.price = 1.99;
float total = apple.weight * apple.price + banana.weight * banana.price;
cout << "Total price = " << total;
```

Total price = 44.95

```
[15]: // declaring and initializing using uniform initializer
Product mango = {15, 2.5};
Product cherry = {10, 2.99};
```

```
[6]: Student_T stu1;
```

```
[7]: stu1.name.fName = "John";
stu1.name.MI = 'E';
stu1.name.lName = "Smith";
stu1.tests[0] = 95;
stu1.tests[1] = 100;
stu1.tests[2] = 98;
```

1.4.1 visualize with pythontutor.com

<https://goo.gl/hbhJdW>

```
[9]: float testAvg = (stu1.tests[0] + stu1.tests[1] + stu1.tests[2])/3;
```

```
[9]: { 95f, 100f, 98f }
```

1.5 aggregate operations on struct types

- assignment is allowed as long as rhs is same struct type as the lhs
 - can pass struct object to functions both by value and reference
- comparison is NOT allowed
 - need to compare corresponding members if they're comparable
- input/output is NOT allowed
 - need to input and output one member at a time

```
[8]: Student_T stu2 = stu1;
Student_T stu3, stu4;
```

```
[14]: // NOT allowed
cout << stu2;
```

input_line_27:3:6: **error:** invalid operands to binary

expression ('std::_1::ostream' (aka 'basic_ostream<char>') and

'Student_T')

cout << stu2;

~~~~ ^ ~~~~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:220:20:

note: candidate function not viable: no known conversion from

'Student\_T' to 'const void \*' for

```

    1st argument; take the address of the argument with &
    basic_ostream& operator<<(const void* __p);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:196:20:
note: candidate function not viable: no known conversion from
'Student_T' to
    'std::__1::basic_ostream<char> &(*) (std::__1::basic_ostream<char> &)' for
1st
    argument
    basic_ostream& operator<<(basic_ostream& (*__pf)(basic_ostream&))
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:200:20:
note: candidate function not viable: no known conversion from
'Student_T' to
    'basic_ios<std::__1::basic_ostream<char, std::__1::char_traits<char>
>::char_type,
    std::__1::basic_ostream<char, std::__1::char_traits<char> >::traits_type>
    &(*) (basic_ios<std::__1::basic_ostream<char, std::__1::char_traits<char>
    >::char_type, std::__1::basic_ostream<char, std::__1::char_traits<char>
    >::traits_type> &)' (aka 'basic_ios<char, std::__1::char_traits<char> >
    &(*) (basic_ios<char, std::__1::char_traits<char> > &)' for 1st
argument
    basic_ostream& operator<<(basic_ios<char_type, traits_type>&
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:205:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'std::__1::ios_base
    &(*) (std::__1::ios_base &)' for 1st argument
    basic_ostream& operator<<(ios_base& (*__pf)(ios_base&))
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:208:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'bool' for 1st
    argument
    basic_ostream& operator<<(bool __n);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:209:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'short' for 1st
    argument
    basic_ostream& operator<<(short __n);

```

^  
/Users/rbasnet/miniconda3/include/c++/v1/ostream:210:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'unsigned short' for

1st argument  
basic\_ostream& operator<<(unsigned short \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:211:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'int' for 1st

argument  
basic\_ostream& operator<<(int \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:212:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'unsigned int' for

1st argument  
basic\_ostream& operator<<(unsigned int \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:213:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'long' for 1st

argument  
basic\_ostream& operator<<(long \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:214:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'unsigned long' for

1st argument  
basic\_ostream& operator<<(unsigned long \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:215:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'long long' for 1st

argument  
basic\_ostream& operator<<(long long \_\_n);  
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:216:20:

note: candidate function not viable: no known conversion from  
'Student\_T' to 'unsigned long long'

```

    for 1st argument
    basic_ostream& operator<<(unsigned long long __n);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:217:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'float' for 1st
    argument
    basic_ostream& operator<<(float __f);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:218:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'double' for 1st
    argument
    basic_ostream& operator<<(double __f);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:219:20:
note: candidate function not viable: no known conversion from
'Student_T' to 'long double' for
    1st argument
    basic_ostream& operator<<(long double __f);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:221:20:
note: candidate function not viable: no known conversion from
'Student_T' to
    'basic_streambuf<std::__1::basic_ostream<char, std::__1::char_traits<char>
    >::char_type, std::__1::basic_ostream<char, std::__1::char_traits<char>
    >::traits_type> *' (aka 'basic_streambuf<char, std::__1::char_traits<char>
> *') for
    1st argument
    basic_ostream& operator<<(basic_streambuf<char_type, traits_type>* __sb);
    ^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:757:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'char' for 2nd
    argument
operator<<(basic_ostream<_CharT, _Traits>& __os, char __cn)
^

/Users/rbasnet/miniconda3/include/c++/v1/ostream:790:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'char' for 2nd
    argument

```

```

operator<<(basic_ostream<char, _Traits>& __os, char __c)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:797:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'signed char' for
    2nd argument
operator<<(basic_ostream<char, _Traits>& __os, signed char __c)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:804:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'unsigned char' for
    2nd argument
operator<<(basic_ostream<char, _Traits>& __os, unsigned char __c)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:818:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'const char *' for
    2nd argument
operator<<(basic_ostream<_CharT, _Traits>& __os, const char* __strn)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:864:1:
note: candidate function not viable: no known conversion from
'Student_T' to 'const char *' for
    2nd argument
operator<<(basic_ostream<char, _Traits>& __os, const char* __str)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:871:1:
note: candidate function not viable: no known conversion from
'Student_T' to
    'const signed char *' for 2nd argument
operator<<(basic_ostream<char, _Traits>& __os, const signed char* __str)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:879:1:
note: candidate function not viable: no known conversion from
'Student_T' to
    'const unsigned char *' for 2nd argument
operator<<(basic_ostream<char, _Traits>& __os, const unsigned char* __str)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:1063:1:
note: candidate function not viable: no known conversion from

```

```

'Student_T' to
    'const std::__1::error_code' for 2nd argument
operator<<(basic_ostream<_CharT, _Traits>& __os, const error_code& __ec)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:750:1:
note: candidate template ignored: deduced conflicting types for
parameter '_CharT'
    ('char' vs. 'Student_T')
operator<<(basic_ostream<_CharT, _Traits>& __os, _CharT __c)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:811:1:
note: candidate template ignored: could not match 'const _CharT
*' against 'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os, const _CharT* __str)
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:1046:1:
note: candidate template ignored: could not match
'basic_string<type-parameter-0-0,
    type-parameter-0-1, type-parameter-0-2>' against 'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os,
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:1054:1:
note: candidate template ignored: could not match
'basic_string_view<type-parameter-0-0,
    type-parameter-0-1>' against 'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os,
~

/Users/rbasnet/miniconda3/include/c++/v1/ostream:1071:1:
note: candidate template ignored: could not match
'shared_ptr<type-parameter-0-2>' against
    'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os, shared_ptr<_Yp> const& __p)
~

/Users/rbasnet/miniconda3/include/c++/v1/iomanip:362:1:
note: candidate template ignored: could not match
'__iom_t8<type-parameter-0-2>' against
    'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os, const __iom_t8<MoneyT>& __x)

```



~/Users/rbasnet/miniconda3/include/c++/v1/iomanip:572:33:

note: candidate template ignored: could not match

```
'__quoted_output_proxy<type-parameter-0-0,  
    type-parameter-0-2, type-parameter-0-1>' against 'Student_T'  
basic_ostream<_CharT, _Traits>& operator<<(  
    ^
```

~/Users/rbasnet/miniconda3/include/c++/v1/iomanip:592:33:

note: candidate template ignored: could not match

```
'__quoted_proxy<type-parameter-0-0,  
    type-parameter-0-1, type-parameter-0-2>' against 'Student_T'  
basic_ostream<_CharT, _Traits>& operator<<(  
    ^
```

~/Users/rbasnet/miniconda3/include/c++/v1/ostream:1036:1:

note: candidate template ignored: requirement

```
'!is_lvalue_reference<basic_ostream<char> &>::value' was not satisfied  
[with _Stream  
    = std::__1::basic_ostream<char> &, _Tp = Student_T]  
operator<<(_Stream&& __os, const _Tp& __x)  
    ^
```

~/Users/rbasnet/miniconda3/include/c++/v1/valarray:4105:1:

note: candidate template ignored: substitution failure [with

```
_Expr1 =  
    std::__1::basic_ostream<char>, _Expr2 = Student_T]: no type named  
'value_type' in  
    'std::__1::basic_ostream<char>'  
operator<<(const _Expr1& __x, const _Expr2& __y)  
    ^
```

~/Users/rbasnet/miniconda3/include/c++/v1/valarray:4120:1:

note: candidate template ignored: substitution failure [with

```
_Expr =  
    std::__1::basic_ostream<char>]: no type named 'value_type' in  
    'std::__1::basic_ostream<char>'  
operator<<(const _Expr& __x, const typename _Expr::value_type& __y)  
    ^
```

~/Users/rbasnet/miniconda3/include/c++/v1/valarray:4136:1:

note: candidate template ignored: substitution failure [with

```
_Expr = Student_T]: no type named  
'value_type' in 'Student_T'  
operator<<(const typename _Expr::value_type& __x, const _Expr& __y)
```

```

/Users/rbasnet/miniconda3/include/c++/v1/ostream:1078:1:
note: candidate template ignored: could not match
'bitset<_Size>' against 'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os, const bitset<_Size>& __x)
~

/Users/rbasnet/miniconda3/include/c++/v1/iomanip:482:1:
note: candidate template ignored: could not match
'__iom_t10<type-parameter-0-0>' against
'Student_T'
operator<<(basic_ostream<_CharT, _Traits>& __os, const __iom_t10<_CharT>& __x)
~

```

Interpreter Error:

```

[12]: cout << stu2.name.fName << '\n';
      cout << stu1.name.fName << '\n';
      stu4 = stu3 = stu2; // copy stu2 to stu3; copy stu3 to stu4

```

John  
John

[12]: @0x1046b6918

```

[13]: // NOT allowed!
      if (stu2 == stu1)
          cout << "two students are equal!"

```

```

input_line_26:2:11: error: invalid operands to binary
expression ('Student_T' and 'Student_T')
if (stu2 == stu1)
    ~~~~ ^ ~~~~

```

Interpreter Error:

```

[12]: if (stu2.name.fName == stu1.name.fName)
 cout << "stu2 and stu1 have same first names.\n";
 else
 cout << "stu2 and stu1 have different first names.\n";

```

stu2 and stu1 have same first names.

## 1.6 passing struct types to functions

- can be passed both by value and reference
- pass by value
  - actual parameter data is copied to formal parameter, member by member
  - less efficient; use it with fundamental types
- pass by reference
  - actual parameter's memory location is passed so actual and formal parameters become alias
  - more efficient as only 4 or 8 bytes memory address is passed
  - use it with struct and class user-defined types

```
[9]: // passed by value
void printStudent(Student_T s) {
 cout << "full name: " << s.name.fName << " " << s.name.MI << " " << s.name.
 ↪lName << '\n';
 cout << "test scores: " << s.tests[0] << " " << s.tests[1] << " " << s.
 ↪tests[2] << '\n';
}
```

```
[13]: printStudent(stu1);
```

```
name: John E Smith
test scores: 95 100 98
```

```
[14]: printStudent(stu4);
```

```
name: John E Smith
test scores: 95 100 98
```

```
[16]: // passed by value
void printStudent1(Student_T &s) {
 cout << "full name: " << s.name.fName << " " << s.name.MI << " " << s.name.
 ↪lName << '\n';
 cout << "test scores: " << s.tests[0] << " " << s.tests[1] << " " << s.
 ↪tests[2] << '\n';
}
```

```
[20]: // stu1 and stu2 are passed by reference; become alias to s formal parameter
stu2.name = {"Jake", 'J', "Jordan"};
stu2.tests[0] = 100;
stu2.tests[1] = 100;
stu2.tests[2] = 100;
printStudent1(stu1);
printStudent1(stu2)
```

```
name: John E Smith
test scores: 95 100 98
name: Jake J Jordan
test scores: 100 100 100
```

## 1.7 array of struct types

- array can be created to hold 1 or more records (struct objects) of same type
- e.g. store data of whole class, department, university, etc.

```
[21]: Student_T CS2[30];
```

```
[22]: Student_T newStu = {{ "Mary", 'M', "Stark"}, {"Joe", 'J', "Stark"}, {95, 75, 100}};
```

```
[23]: CS2[0] = stu1;
 CS2[1] = stu2;
 CS2[2] = stu3;
 CS2[3] = stu4;
 CS2[4] = newStu;
```

```
[25]: for(int i=0; i<5; i++) {
 printStudent1(CS2[i]);
 }
```

```
name: John E Smith
test scores: 95 100 98
name: Jake J Jordan
test scores: 100 100 100
name: John E Smith
test scores: 95 100 98
name: John E Smith
test scores: 95 100 98
name: Mary M Stark
test scores: 95 75 100
```

```
[]:
```