



Module 26

Instructors: Abir
Das and
Sourangshu
Bhattacharya

Type Casting

Comparison

Built-in Type

Promotion &
Demotion

Unrelated Classes

Inheritance Hierarchy

Upcast

Downcast

Module Summary

Module 26: Programming in C++

Polymorphism: Part 1: Type Casting

Instructors: Abir Das and Sourangshu Bhattacharya

Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur

{*abir, sourangshu*}@cse.iitkgp.ac.in

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by **Prof. Partha Pratim Das**



Module Objectives

- Understand type casting and the difference between implicit and explicit casting
- Understand type casting in a class hierarchy
- Understand the notions of upcast and downcast

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Module Outline

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Module Summary

- 1 Type Casting
 - Basic Notions
 - Comparison of Implicit and Explicit Casting
 - Built-in Type
 - Promotion & Demotion
 - Unrelated Classes
 - Inheritance Hierarchy
 - Upcast
 - Downcast

- 2 Module Summary



Type Casting: Basic Notions

- Casting is performed when a *value (variable) of one type* is used in place of *some other type*. Converting an expression of a given type into another type is known as **type-casting**

```
int i = 3;  
double d = 2.5;
```

```
double result = d / i; // i is cast to double and used
```

- Casting can be **implicit** or **explicit**

```
d = i;           // implicit: int to double  
i = d;           // implicit: warning: '=' : conversion from 'double' to 'int': possible loss of data  
d = (double)i;  // explicit: int to double  
i = (int)d;     // explicit: double to int
```

- Casting Rules can be grossly classified for:
 - Built-in types
 - Unrelated types
 - Inheritance hierarchy (static)
 - Inheritance hierarchy (dynamic)



Comparison of Implicit and Explicit Casting

Implicit Casting

- Done *automatically*
 - *No data loss*, for promotion
Compiler will be *silent*
 - *Possible data loss*, for demotion
Compiler will issue *warning*
 - Requires *no special syntax*
-
- *Avoid, if possible*
 - *Possible only* in *static* time
 - *May be disallowed* for *User-Defined Types*, but *cannot be disallowed* for *built-in types*

Explicit Casting

- Done *programmatically*
 - Data loss *may or may not take place*
Compiler will be *silent*
-
- Requires *cast operator* for conversion
C style operator: (`< type >`)
C++ style operators:
`const_cast`,
`static_cast`,
`dynamic_cast`, and
`reinterpret_cast`
 - *Avoid C style cast*
Use C++ style cast
 - *Possible* in *static* as well as *dynamic* time
 - *May be defined* for *User-Defined Types*



Type Casting Rules: Built-in Type

- Various type castings are possible between built-in types

```
int i = 3;
double d = 2.5;
```

```
double result = d / i; // i is cast to double and used
```

- Casting rules are defined between numerical types, between numerical types and pointers, and between pointers to different numerical types and `void`
- Casting can be **implicit** or **explicit**

```
int i = 3;
double d = 2.5, *p = &d;
```

```
d = i;           // implicit: int to double
i = d;           // implicit: warning: '=' : conversion from 'double' to 'int': possible loss of data
```

```
d = (double)i;  // explicit: int to double
i = (int)d;     // explicit: double to int
```

```
i = p;          // error: '=' : cannot convert from 'double *' to 'int'
i = (int)p;     // explicit: double * to int
```



Type Casting Rules: Built-in Type: Numerical Types

- Casting is *safe* for *promotion* (All the data types of the variables are upgraded to the data type of the variable with larger data type)

`bool` → `char` → `short int` → `int` → `unsigned int` → `long` → `unsigned` →
`long long` → `float` → `double` → `long double`

- Casting in built-in types *does not invoke* any conversion function. It only *re-interprets* the binary representation
- Casting is *unsafe* for *demotion* – may lead to loss of data



Type Casting Rules: Built-in Type: Pointer Types

- Implicit casting between different pointer types is not allowed
- Any pointer can be implicitly cast to `void*` (with loss of type); but `void*` cannot be implicitly cast to any pointer type
- Conversion between array and corresponding pointer is not type casting – these are two different syntactic forms for accessing the same data

```
int i = 1, *p = &i, a[10]; double d = 1.1, *q = &d; void *r;
```

```
q = p;           // error: cannot convert 'int*' to 'double*'
p = q;           // error: cannot convert 'double*' to 'int*'
q = (double*)p; // Okay
p = (int*)q;     // Okay
```

```
r = p;           // Okay to convert from 'int*' to 'void*'
p = r;           // error: invalid conversion from 'void*' to 'int*'
p = (int*)r;     // Okay
```

```
p = a;           // Okay by array pointer duality. p[i], a[i], *(p+i), *(a+i) are equivalent
a = p;           // error: incompatible types in assignment of 'int*' to 'int[10]'
```




Type Casting Rules: Built-in Type: Pointer Types

- Implicit casting between pointer type and numerical type is *not allowed*
- However, explicit casting between pointer and integral type (`int` or `long` etc.) is a common practice to support various tasks like *serialization* (save a file) and *de-serialization* (open a file)
- Care should be taken with these explicit cast to ensure that the integral type is of the *same size* as of the pointer. That is: `sizeof(void*) = sizeof(< integraltype >)`

```
int i, *p = 0; long j;
```

```
// sizeof(i) = sizeof(int) = 4
// sizeof(j) = sizeof(long) = 8
// sizeof(p) = sizeof(int*) = sizeof(void*) = 8
```

```
i = p; // error: invalid conversion from 'int*' to 'int'
p = i; // error: invalid conversion from 'int' to 'int*'
```

```
i = (int)p; // error: cast from 'int*' to 'int' loses precision
p = (int*)i; // warning: cast to pointer from integer of different size
```

```
j = (long)p; // Okay
p = (int*)j; // Okay
```

- Here, the conversion should be done between `int*` and `long` and not between `int*` and `int`



Type Casting Rules: Unrelated Classes

- **(Implicit)** Casting between *unrelated classes is not permitted*

```
class A { int i; };  
class B { double d; };
```

```
A a;  
B b;
```

```
A *p = &a;  
B *q = &b;
```

```
a = b; // error: binary '=' : no operator which takes a right-hand operand of type 'B'  
a = (A)b; // error: 'type cast' : cannot convert from 'B' to 'A'
```

```
b = a; // error: binary '=' : no operator which takes a right-hand operand of type 'A'  
b = (B)a; // error: 'type cast' : cannot convert from 'A' to 'B'
```

```
p = q; // error: '=' : cannot convert from 'B *' to 'A *'  
q = p; // error: '=' : cannot convert from 'A *' to 'B *'
```

```
p = (A*)&b; // explicit on pointer: type cast is okay for the compiler  
q = (B*)&a; // explicit on pointer: type cast is okay for the compiler
```



Type Casting Rules: Unrelated Classes

- **Forced** Casting between *unrelated classes is dangerous*

```
class A { public: int i; };  
class B { public: double d; };
```

```
A a;  
B b;
```

```
a.i = 5;  
b.d = 7.2;
```

```
A *p = &a;  
B *q = &b;
```

```
cout << p->i << endl; // prints 5  
cout << q->d << endl; // prints 7.2
```

```
p = (A*)&b; // Forced casting on pointer: Dangerous  
q = (B*)&a; // Forced casting on pointer: Dangerous
```

```
cout << p->i << endl; // prints -858993459: GARBAGE  
cout << q->d << endl; // prints -9.25596e+061: GARBAGE
```



Type Casting Rules: Inheritance Hierarchy

- Casting on a **hierarchy** is *permitted in a limited sense*

```
class A { };  
class B : public A { };
```

```
A *pa = 0;  
B *pb = 0;  
void *pv = 0;
```

```
pa = pb; // UPCAST: Okay
```

```
pb = pa; // DOWNCAST: error: '=' : cannot convert from 'A *' to 'B *'
```

```
pv = pa; // Okay, but lose the type for A * to void *
```

```
pv = pb; // Okay, but lose the type for B * to void *
```

```
pa = pv; // error: '=' : cannot convert from 'void *' to 'A *'
```

```
pb = pv; // error: '=' : cannot convert from 'void *' to 'B *'
```



Type Casting Rules: Inheritance Hierarchy

- **Up-Casting** is *safe*

```
class A { public: int dataA_; };  
class B : public A { public: int dataB_; };
```

```
A a;  
B b;
```

```
a.dataA_ = 2;  
b.dataA_ = 3;  
b.dataB_ = 5;
```

```
A *pa = &a;  
B *pb = &b;
```

```
cout << pa->dataA_ << endl; // prints 2  
cout << pb->dataA_ << " " << pb->dataB_ << endl; // prints 3 5
```

```
pa = &b;
```

```
cout << pa->dataA_ << endl; // prints 3  
cout << pa->dataB_ << endl; // error: 'dataB_' : is not a member of 'A'
```



Type Casting Rules: Inheritance Hierarchy

- **Down-Casting** is *risky*

```
class A { public: int dataA_; };  
class B : public A { public: int dataB_; };
```

```
A a;  
B b;
```

```
a.dataA_ = 2;  
b.dataA_ = 3;  
b.dataB_ = 5;
```

```
B *pb = (B*)&a;           // Forced downcast
```

```
cout << pb->dataA_ << endl; // prints 2  
cout << pb->dataB_ << endl; // Compilation okay. Prints garbage for 'dataB_' -- no 'dataB_' in 'A' object
```



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- Introduced type casting
- Understood the difference between implicit and explicit type casting
- Introduced the notions of Casting in a class hierarchy – upcast and downcast