C++ Course 5: IO streams. Type casts. enum class.

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Using C++ compilers

gcc:

g++ -o myprog main.cpp file1.cpp file2.cpp

clang:

clang -o myprog main.cpp file1.cpp file2.cpp

cl (Microsoft):

cl /o myprog main.cpp file1.cpp file2.cpp

myprog = Name of the compiled program (EXE on Windows)

main.cpp file1.cpp file2.cpp = C++ source files

How to build a CMake project ?

```
mkdir build
cd build
cmake ..
cmake --build .
```

Rebuild after you have edited some source files ...

```
cmake --build .
```

Using *generators* (Example: Windows, MinGW)

```
mkdir build
cd build
cmake -G "MinGW Makefiles" ..
cmake --build .
```

CMake does not call the C++ compiler directly.
Generators use low-level build systems (**make**, **nmake**, **ninja**, **...**)
and IDEs (Visual Studio, Code.Blocks, xcode)

Enumerated type (enum)

Enumerated types : unscoped (**enum**) and scoped (**enum class**, C++ 11)
Перечисляемые типы: **enum**, **enum class**

```
enum Color {red, green, blue, cyan, magenta, yellow, orange};
```

Variable declaration - Объявление переменной

```
Color a = magenta;                // Used without any scope ! BAD !
Color b = a;
cout << "b = " << b << endl;      // Can print, prints 4
int i = a;                        // Can assign to an int variable
cout << "i = " << i << endl;      // Prints 4
```

Color can be used in the **switch** statement

```
switch (b) {
case (red):
        ...
```

enum class: scoped version of enum

enum class is scoped. It's NOT a class ! Can be cast to **int**

```
enum class Color {red, green, blue, cyan, magenta, yellow, orange};

Color a = Color::magenta;                 // magenta is in scope Color:: ! GOOD!
Color b = a;
cout << "b = " << (int) b << endl;        // Explicit cast, prints 4
int i = (int) a;                          // Explicit cast
out << "i = " << i << endl;               // Prints 4
```

You can use **enum** inside **class**, (small) **namespace**, function
Можно использовать **enum** внутри класса, (малого) **namespace**, функции

Otherwise use **enum class** !
Иначе использовать **enum class** !

enum: specify numerical values

```
enum Color {red = 17, green, blue, cyan, magenta, yellow, orange};
cout << red << " " << green << " " << blue << " " << cyan << " " << magenta <<
        " " << yellow << " " << orange << endl;
```

```
17 18 19 20 21 22 23
```

Danger ! Опасность !

```
enum Color {red, green, blue, cyan = 1, magenta, yellow, orange};
```

```
0 1 2 1 2 3 4
```

Values are repeated !!! Величины повторяются !!!

Using **enum** for constants, anonymous unscoped **enum**

```
enum {OK = 0, FILE_NOT_FOUND = 1234, BAD_DATA = 1235, IO_ERRROR = 1236};
int i = readData();
switch (i) {
    ...
```

Enum underying type

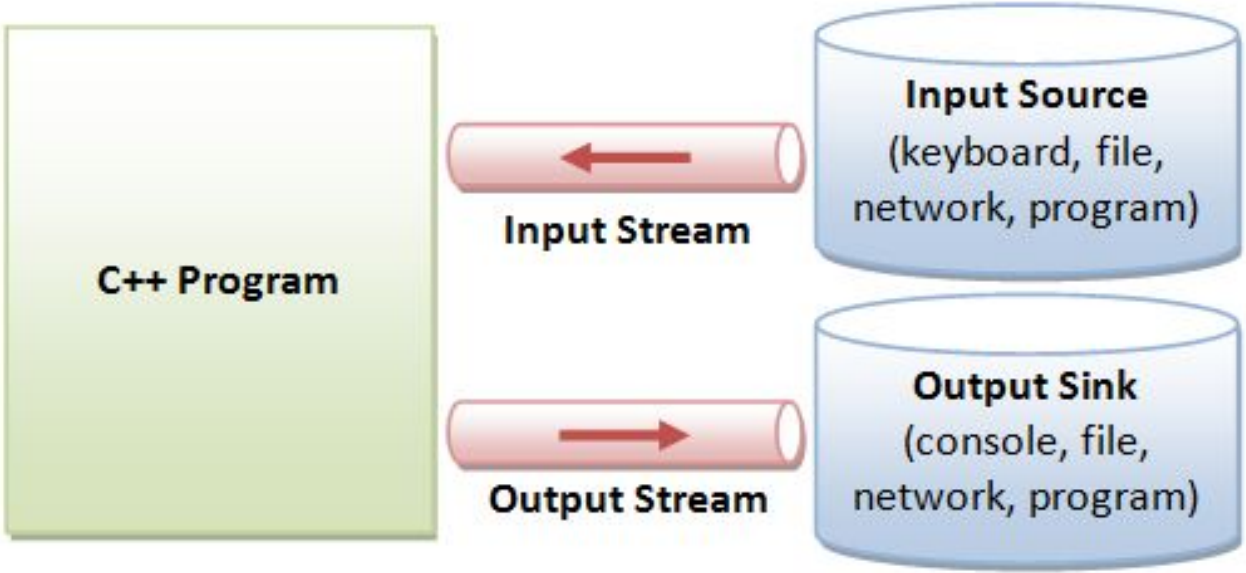
Тип, в котором хранится **enum**

```
enum Color1 : int {red, green, blue, cyan , magenta, yellow, orange};
enum class Color2 : unsigned char {red, green, blue, cyan , magenta, yellow, orange};
enum class Color3 : long long {red, green, blue, cyan , magenta, yellow, orange};
sizeof(Color1) == 4
sizeof(Color2) == 1
sizeof(Color3) == 8
```

The default type (тип по умолчанию) is **int** (4 bytes)

Use **unsigned char** (1 byte) to save memory !
Используйте **unsigned char** (1 байт), чтобы экономить память !

I/O streams



Internal Data Formats:

- Text: `char`, `wchar_t`
- `int`, `float`, `double`, etc.

External Data Formats:

- Text in various encodings (US-ASCII, ISO-8859-1, UCS-2, UTF-8, UTF-16, UTF-16BE, UTF16-LE, etc.)
- Binary (raw bytes)

Standard streams cin, cout, cerr, clog

cin : Standard input - стандартный ввод (buffer)
cin : Standard output - стандартный вывод (buffer)
cerr : Standard error output - стандартный вывод ошибок (no buffer)
clog : Standard error output to **cerr** with buffer ?

operator **>>** : Input operator - операция ввода
operator **<<** : Input operator - операция вывода

```
double c, d;
cout << "Enter c, d :" << endl;
cin >> c >> d;
cout << "c = " << c << " , d = " << d << " , c*d = " << c*d << endl;
cerr << "Fatal error : file " << fileName << " not found ! \n";
```

Operators **>>, <<** return the stream itself (возвращают поток)
For example: **cin >> c** returns **cin**.

Reading strings

```
string name;
cout << "Your full name ?" << endl;
cin >> name;
```

Type in the console: Sir Philip Anthony Hopkins

name == ????

Reading strings

```
string name;
cout << "Your full name ?" << endl;
cin >> name;
```

Type in the console: Sir Philip Anthony Hopkins

name == "Sir" !!!

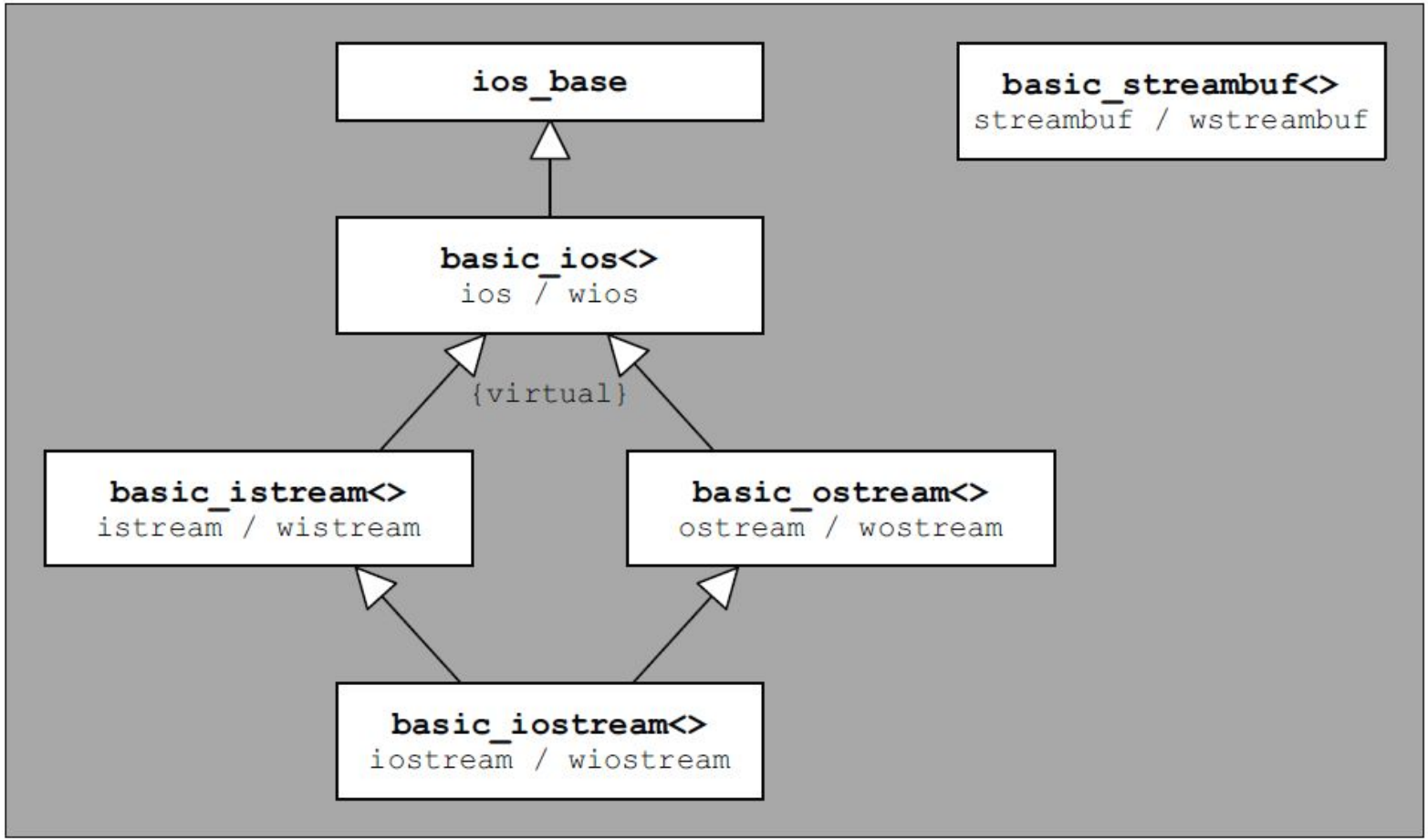
The proper way to do it :

getline(cin, name);

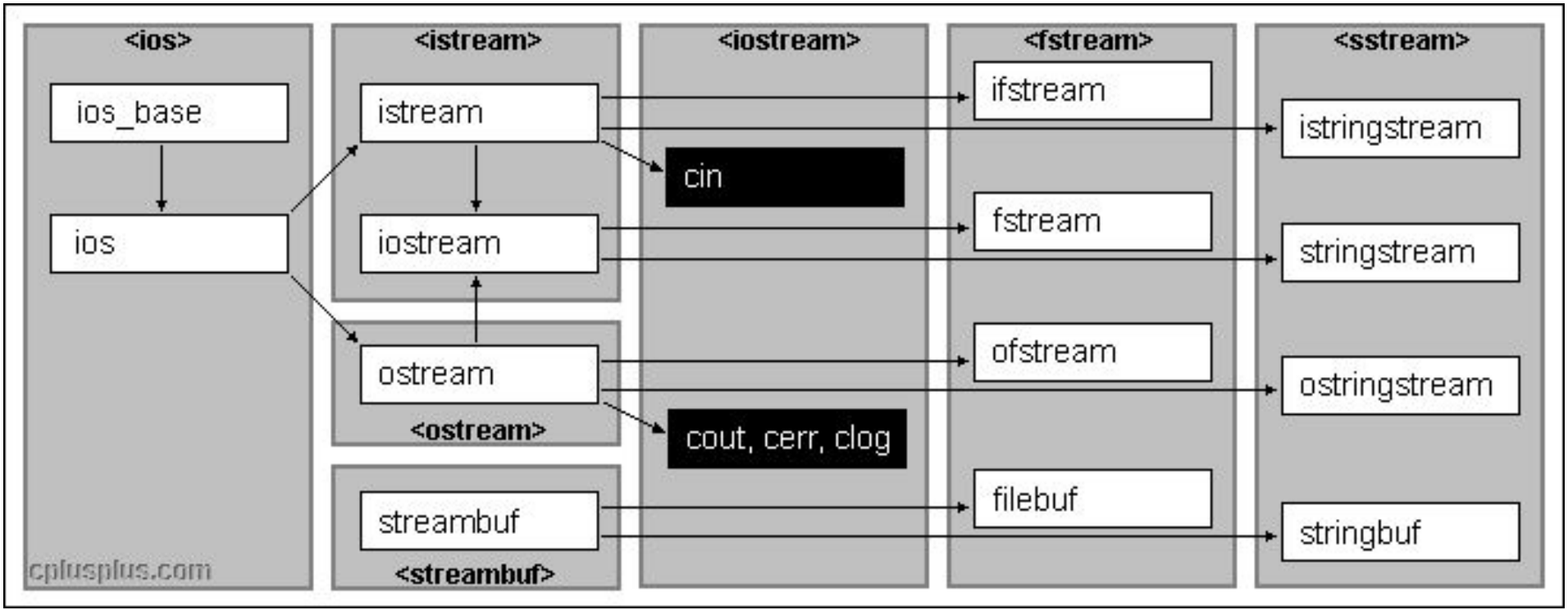
Now **name** == "Sir Philip Anthony Hopkins"

getline() reads until EOL (End of Line)

I/O stream classes (diamond problem !)



I/O stream classes and headers



Stream status and errors

Status bits:

good = Everything is OK
fail = Error (e.g. failed to red **int**, or EOF)
bad = Serious error
eof = End of file

Class methods: **cin.good()**, **cin.fail()**, **cin.bad()**, **cin.eof()**
Clear after error: **cin.clear()**
Cast to **bool** : same as (**!cin.fail()**) :

```
int a, b;
if (cin >> a >> b)
        cout << "a = " << a << ", b = " << b << endl;
else
        cerr << "Error !" << endl;
```

Exceptions in I/O streams

By default **istream**, **ostream** throw no exceptions
По умолчанию **istream**, **ostream** не кидают иксепшены (исключения)

Turn on exceptions (включить иксепшены) for **cin**:

```
cin.exceptions (ios::eofbit | ios::failbit | ios::badbit);
```

Now **cin** throws **ios_base::failure** if anything is wrong!
Теперь **cin** кидает **ios_base::failure** если какие-то проблемы!

```
try {
        cin >> a >> b;
        ...
} catch (const ios_base::failure & e) {
        cerr << e. what() << endl;
}
```

String streams: istringstream, ostringstream, stringstream

To use strings as streams -- Использовать строки как потоки
Use **str()** (getter and setter) to access the underlying string

```
istringstream iss("13.98  17.32");
ostringstream oss;
double a, b;
iss >> a >> b;
oss << "a = " << a << " , b = " << b << " , a*b = " << a*b << endl;
cout << "oss.str() = " << oss.str();    // Contents of oss
```

If we want to reuse **iss** -- Если мы хотим снова использовать **iss :**

```
iss.str("3.0 7.0");      // Change the string in iss
iss.clear();             // To avoid failure on EOF !
```

We need **clear()** to clear the EOF bit !

File streams : ifstream, ofstream, fstream

To open an input file:

ifstream in("in_file.txt");

or

ifstream in;

in.open("in_file.txt");

To create/overwrite output file:

ofstream out("out_file.txt");

To append at the end of file:

ofstream out("out_file.txt", ios::app | ios::out);

To close a file:

out.close();

Note: No need to do that, destructor calls **close()** !

Stream open modes

ios::app seek to the end of stream before each write
ios::binary open in binary mode
ios::in open for reading
ios::out open for writing
ios::trunc discard the contents of the stream when opening
ios::ate seek to the end of stream immediately after open

Joined by the **|** (bitwise OR) operator, for example

```
ofstream o1("out1.dat", ios::out | ios::binary);   // Out, replace, binary
ofstream o2("out2.dat", ios::out | ios::app | ios::binary);   // Out, append, binary
ifstream  i1("in1.dat", ios::in | ios::binary);   // In, binary
```

Stream methods and functions

Read/write **char**, C-strings, **streambuf**

get()

put()

Read/write **string**

getline() (method)

getline() (function)

<< (write)

Read/write buffers:

read()

write()

readsome()

Copy files : 2 ways

Using **get**, **put** :

```
char c;
while (in.get(c))
    out.put(c);
```

Using **read**, **write** :

```
constexpr streamsize SIZE = 1024;   // Buffer size
char buf[SIZE];                     // Buffer
streamsize count;

do {
    in.read(buf, SIZE);         // Read up to SIZE chars to the buffer
    count = in.gcount();        // Get the actual count
    out.write(buf, count);       // Write count chars
} while (count > 0);            // Exit if count == 0
```

gcount() returns number of bytes actually read, up to **SIZE**.

C++ and unicode: Trouble with wchar_t, wstring, wcin, wcout

Idea: **wchar_t** is a wide (16 or 32 bit) character. **wstring**, **wcin**, **wcout**.
Why it is bad? Почему это плохо?

1. No guarantee it is UFT-16. Никакой гарантии что это UTF-16.
2. **wcin**/**wcout** depend on **locale**. Используют **locale**.

locale is compiler and OS-dependent! **locale** зависят от ОС и компилятора!

Probably works in : Linux, Windows + CL (Microsoft compiler)

MinGW gcc : only **C** and **POSIX** ! No UTF-8 !

Forget about **wchar_t**, **wstring**, **wcin**, **wcout** !
Забудьте про **wchar_t**, **wstring**, **wcin**, **wcout** !

C++ and unicode : use UTF-8 ! And no locales !

1. Your code (*.h, *.cpp) must be in UTF-8 (string literals !).
2. Use **string** (not **string** !) for strings.
3. Use **cin**, **cout**, **ifstream**, **ofstream** with files in UTF-8.
4. Works fine with files, linux console.
5. Some trouble with windows console:
   - Output: type **chcp 65001** in the console
   - Input: I could not fix
6. Could be fixed with windows API if really needed.
7. GUI libraries have their own unicode support, e.g. **ustring** in **gtkmm**.
8. Use C++ 11 **u16string** and **char16_t** if needed. UTF8 <-> UTF16 conversion!

```
cout << "Український текст із літерами ґҐ !"  << endl;
cout << "Svenska bokstäver ÅåÖöÄä !" << endl;
cout << "Hiragana :  あ , い , う , え , お " << endl;
```

Manipulators 1 : Example 5.1

flush	Flush the buffer
endl	'**\n**' + flush the buffer
setw(i)	Set output width to **i**
left, right	Alignment left or right
setfill(c)	Set fill character
(**no**)**boolalpha**	Read/write **bool** as "**true**", "**false**" instead of **0, 1**
fixed, scientific	Notation for doubles
ws	Skip whitespaces (on read)

```
cout.precision(20);              // Set double precision
cout << setw(1) << 1 << setw(2) << 2 << setw(3) << 3 << setw(4) << 4
             << setw(5) << 5 << setw(6) << 6 << endl;
cout << left << setfill('A') << setw(10) << 1
              << right << setfill('B') << setw(10) << 2 << endl;
cout << scientific << uppercase << setfill('&') << setw(30) << 1.0/3 << endl;
```

```
1 2  3   4    5     6
1AAAAAAAAABBBBBBBBB2
&&&3.33333333333333314830E-001
```

Manipulators 2: dec, oct, hex

hex	Hexadecimal
oct	Octal
dec	Decimal
(**no**)**showbase**	Show base (e.g. 0x1a4 instead of 1a4)
(**no**)**uppercase**	Uppercase letters in hex numbers, double exp

```
int i = 45;
cout << "Dec : " << i << " " <<  showbase << i  << noshowbase << endl;
cout << "Oct : "<< oct << i << " " << showbase << i << dec <<
noshowbase<<endl;
cout << "Hex : "<< hex << i << " " << showbase << i << dec <<
noshowbase<<endl;
cout << "HEX : " << uppercase << hex << i << " "  << showbase << i  << dec
```

```
Dec : 45 45
Oct : 55 055
Hex : 2d 0x2d
HEX : 2D 0X2D
```

C I/O : printf(), scanf(), puts(), fgets()

C language has files and standard streams: **stdin, stdout, stderr**

```
puts("Enter a, b :");                                  // Print a string to stdout
double a, b;
scanf("%lf %lf", &a, &b);                              // Read a, b. Pointers !
getchar();                                             // Skip newline
printf(" %lf * %lf = %15.10lf\n", a, b, a*b);          // Print stuff

constexpr size_t SIZE = 100;
char s[SIZE];                                          // Buffer for a C-string
puts("Your full name ?");
fgets(s, SIZE, stdin);
printf("Hello %s !!!\n", s);
```

C files : see example 5.2

Using printf() formatting with C++ stream objects?

printf() is nice. Can we use it with C++ stream objects?

Simple example (a *variadic* template):

```
template <typename...  Params>
void print(std::ostream & os, const std::string & fmt, Params... p) {
    constexpr size_t SIZE = 1000;
    static char buffer[SIZE];                    // Hidden global buffer = ugly
    std::snprintf(buffer, SIZE, fmt.c_str(), p...);
    os << buffer;
}
```

Usage example:

```
print(cout, "8.1 = %10.13lf , 9 = %d \n", 8.1, 9);
```

This version:

1. Uses a global buffer of max size 1000, not thread-safe
2. Cannot work with C++ strings or any class objects

Better choice: Boost **format()**

Type conversions (type casts)

Преобразования типов (касты)

Implicit conversions. Неявные преобразования:
Primitive types, pointers to **void ***, pointer upcast, constructors, cast operators

C++-style casts. Conversion from type B to type A:

```
B b;
const_cast<A>(b)          // Remove const from a pointer or reference
static_cast<A>(b)         // Various type conversions
dynamic_cast<A>(b)        // Safe polymorphic cast (pointer or reference)
reinterpret_cast<A>(b)    // Reinterpret memory bytes as different type
```

C-style casts:

```
(A)b                      // Roughly speaking const_cast, static_cast, reinterpret_cast
A(b)                      // In that order
```

Implicit conversions

Неявные преобразования

```
A a;
B b;
b = a;          // A is converted to B
myfunc(a);      // Expects argument of type B
```

Primitive types:

```
float a = 777;   // Possible loss of accuracy
int b = 3.5;     // Loss of accuracy
char c = 1987; // Loss of higher bytes
```

Other types:

```
void * pV = &a;              // Pointer to void *
string s = "Phoenix";        // Constructor : const char[8] to string
bool b(cout);                // Cast operator: ostream to bool
```

Pointer and reference upcast:

```
struct Base{
        virtual void print(){ cout << "Base" << endl;}
};
struct Derived : public Base{
        void print() override { cout << "Derived" << endl;}
};
```

Upcast: **Derived * to Base *, Derived & to Base &**

```
Derived derived;
Base & baseR = derived;
Base * baseP = &derived;
baseR.print();                  // Prints 'Derived' twice, polymorphism works
baseP->print();
```

const_cast: Remove (cast away) const from ptrs, refs

Converts **const type *** to **type *** or **const type &** to **type &** :

```
int a = 17;
const int & crA = a;
int & rA = const_cast<int &>(crA);    // Remove const
rA = 20;
cout << "a = " << a << endl;           // Prints 20

double b = 1.1;
const double * cpB = &b;
double * pB = const_cast<double *>(cpB);    // Remove const
*pB = 2.2;
cout << "b = " << b << endl;           // Prints 2.2
```

static_cast: All "normal" casts

1. Implicit conversion made explicit (and remove warnings)

string s = static_cast<string>("Idiot !");

2. Enum::Class <-> **int**

int i = static_cast<int>(Num::Four);

3. **void *** to any pointer (No checks !)

4. Reference/pointer downcast: **Base *** to **Derived ***, **Base &** to **Derived &**. No checks!

Does not check that the object is of **Derived** class, unsafe !

```
Derived d;
Base & rB = d;
Base * pB = &d;
Derived & rD =  static_cast<Derived &> (rB);    // Downcast
Derived * pD =  static_cast<Derived *> (pB);    // No checks  !
rD.print();                                     // Prints "Derived" twice
pD->print();
```

dynamic_cast: Pointer/reference downcast with checks

Like previous example, but with checks.

```
Derived d;
Base & rB = d;
Base * pB = &d;
Derived & rD =  dynamic_cast<Derived &> (rB);    // Downcast
Derived * pD =  dynamic_cast<Derived *> (pB);    // No checks  !
rD.print();                                      // Prints "Derived" twice
pD->print();
```

throws **bad_cast** (for references) or returns **nullptr** (for pointers) if wrong type

```
Base b2;
Base & rB2 = b2;
Base * pB2 = &b2;
Derived & rD2 = dynamic_cast<Derived &> (rB2);    // throws bad_cast
Derived * pD2 = dynamic_cast<Derived *> (pB2);    // returns nullptr
```

reinterpret_cast, C-style casts

reinterpret_cast interprets memory bytes as a different type
reinterpret_cast Интерпретирует байты памяти как другой тип

```
int i = 17;
int *pI = &i;     // Pointer
long long j = reinterpret_cast<long long>(pI);
```

C-style casts:
const_cast, **static_cast** or **reinterpret_cast** in this order.

```
char c = (char) 2017;
int i = (int) 13.456789;
Derived & rD = (Derived &) rB;
Derived * pD = (Derived *) pB;
```

Thank you for your attention !

title

text