

Title: Template Metaprogramming Tutorial

Date: Jun 28, 2013 01:30 PM

URL: <http://pirsa.org/13060024>

Abstract:

```
Terminal 13:35:06
Documents Files
~/Desk...echFinal
~/Desk...ntrodu...on.cpp
name:emos Mario Koenz
study: interdisciplinary science ETH Zuerich
main subject: physics and computational science
~/Desk...ivation
~/Desk...e_basics
~/Desk...lasses
~/Desk...der_only
~/Desk...an_trait
~/Desk...5_sfinae
~/Desk...ple.cpp
~/Desk...ss.cpp
~/Desk...od.cpp
~/Desk...its.cpp
~/Desk...pitfalls
~/Desk...ramino

49 WAIT_FOR_INPUT()
50 PRINT_YELLOW(" 2: template motivation")
51 WAIT_FOR_INPUT()
52 PRINT_YELLOW(" 3: template basics")
53 WAIT_FOR_INPUT()
54 PRINT_YELLOW(" 4: central mechanism: SFINAE")
55 WAIT_FOR_INPUT()
56 PRINT_YELLOW(" 5: central mechanism: SFINAE")
57 WAIT_FOR_INPUT()
58 PRINT_YELLOW(" 6: pitfalls")
59 WAIT_FOR_INPUT()
60 PRINT_YELLOW(" 7: concept programming")
61 WAIT_FOR_INPUT()
62 PRINT_YELLOW(" 8: summary")
63 WAIT_FOR_INPUT()
64 CLR_SCR()
65 WAIT_FOR_INPUT()
66 PRINT_YELLOW(" majority of the examples works without c++0x")
67 WAIT_FOR_INPUT()
68 PRINT_YELLOW(" those few examples that need c++0x can also be realised with ")
69 WAIT_FOR_INPUT()
70 PRINT_YELLOW(" all examples are available on GitHub")
71 PRINT_YELLOW(" https://github.com/mskoenz/cpp\_template\_examples")
72 WAIT_FOR_INPUT()
73 PRINT_RED(" ask questions if you don't get something!")
74
75 return 42;
76 }
77
```

Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory: /home/msk/Desktop/ProgTechFinal)

Compiler Compilation finished successfully.

Messages

Scribble

Terminal

line: 71 / 77 col: 68 sel: 48 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main

Terminal

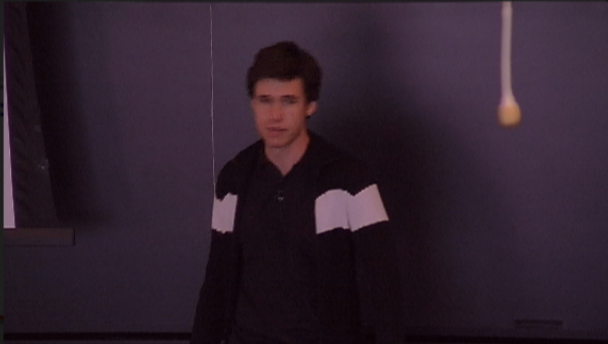
Documents Files

49 WAIT_FOR_INPUT()
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54 PRINT_YELLOW(" interdisciplinary science ETH Zuerich")
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59 WAIT_FOR_INPUT()
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74
75 return 42;
76 }
77

name: **Mario Könz**
study: **interdisciplinary science ETH Zuerich**
main subject: **physics and computational science**
c++ experience: **3 semesters programming techniques with Matthias Troyer**
worked 2 years on the 'ALPS' library
why am I here: **writing my master-thesis with Roger Melko**

Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 71 / 77 col: 68 sel: 4B INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main



Terminal

Documents Files

content

1: demonstration/polymorphism

2: template motivation

3: template basics

```

49  WAIT_FOR_INPUT()
50  PRINT_YELLOW(" 2: template motivation")
51  WAIT_FOR_INPUT()
52  PRINT_YELLOW(" 3: template basics")
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Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory: ...)


Compiler Compilation finished successfully.

Messages

Scribble

Terminal

line: 71 / 77 col: 68 sel: 48 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main




```
Terminal 13:36:24
Documents Files
content
1: demonstration/polymorphism
2: template motivation
3: template basics
4: mean trait
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Compiler Compilation finished successfully.
Messages
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Terminal
line: 71 / 77 col: 68 sel: 48 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```



Terminal

Documents Files

content

1: demonstration/polymorphism

2: template motivation

3: template basics

4: mean trait

5: central mechanism: SFINAE

6: pitfalls

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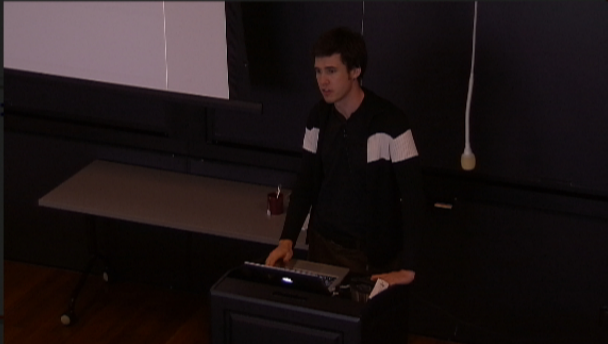
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Messages

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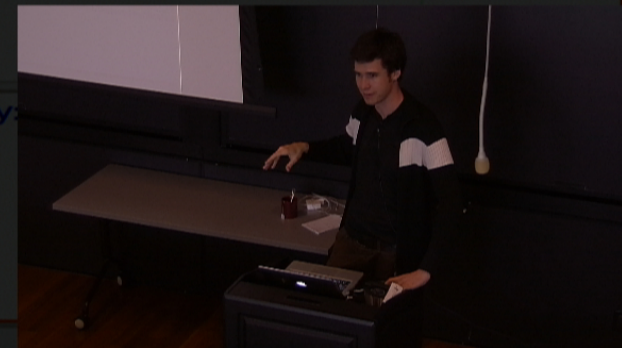
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```
Terminal
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Compiler Compilation finished successfully.
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```
Terminal 13:37:30
Documents Files
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those few examples that need c++0x can also be realised with just boost
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Compiler Compilation finished successfully.
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Terminal
line: 71 / 77 col: 68 sel: 4B INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```




```
01_01_chameleon_type.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Deskt...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Deskt...e_basics
  03_03...on.cpp
~/Deskt...classes
  03_01...er.hpp
  03_01_impl.cpp
  03_01...es.cpp
~/Deskt...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Deskt...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Deskt...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Deskt...pitfalls
  06_01...es.cpp
~/Deskt...gramina

146 // +-----+
147 // |                                     |
148 // |                                     |
149 // +-----+
149 int main(int argc, char* argv[]) {
150 //NEEDS -std=c++0x for shared_ptr
151 CLR_SCR()
152 PRINT_CYAN("press enter to continue")
153
154 chameleon_type foo, bar;
155
156 foo = 3.14;
157 bar = "some_text";
158
159 WAIT_FOR_INPUT() //just hit the enter key to continue
160 PRINT_NAMED(foo)
161 PRINT_NAMED(bar)
162
163 WAIT_FOR_INPUT()
164 PRINT_CALL(double number = foo)
165 PRINT_CALL(std::string string(bar))
166
167 WAIT_FOR_INPUT()
168 PRINT_NAMED(number)
169 PRINT_NAMED(string)
170
171 foo = "changed_to_string";
172 bar = 42;
173
174 WAIT_FOR_INPUT()

Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory: /home/msk/Desktop/ProgTechFinal
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 154 / 180 col: 19 sel: 8 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```

```
01_01_chameleon_type.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt..._demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Deskt...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Deskt...e_basics
  03_03_...on.cpp
~/Deskt...classes
  03_01_...er.hpp
  03_01_...impl.cpp
  03_01_...es.cpp
~/Deskt...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Deskt...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Deskt...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Deskt...pitfalls
  06_01_...es.cpp
~/Deskt...gramina

152     PRINT_CYAN("press enter to continue")
153
154     chameleon_type foo, bar;
155
156     foo = 3.14;
157     bar = "some_text";
158
159     WAIT_FOR_INPUT() //just hit the enter key to continue
160     PRINT_NAMED(foo)
161     PRINT_NAMED(bar)
162
163     WAIT_FOR_INPUT()
164     PRINT_CALL(double number = foo)
165     PRINT_CALL(std::string string(bar))
166
167     WAIT_FOR_INPUT()
168     PRINT_NAMED(number)
169     PRINT_NAMED(string)
170
171     foo = "changed to string";
172     bar = 42;
173
174     WAIT_FOR_INPUT()
175     PRINT_NAMED(foo)
176     PRINT_NAMED(bar)
177
178     return 0;
179 }
180

Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory: /home/msk/Desktop/ProgTechFinal
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 171 / 180 col: 29 sel: 25 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```



```
Terminal 13:41:01
press enter to continue YAN("press enter to continue")
153
154     chameleon_type foo, bar;
155
156     foo = 3.14;
157     bar = "some_text";
158
159     WAIT_FOR_INPUT() //just hit the enter key to continue
160     PRINT_NAMED(foo)
161     PRINT_NAMED(bar)
162
163     number = 3.14
164     string = some_text
165     WAIT_FOR_INPUT()
166     PRINT_CALL(double number = foo)
167     PRINT_CALL(std::string string(bar))
168
169     foo = changed_to_string
170     bar = 42
171     PRINT_NAMED(number)
172     PRINT_NAMED(string)
173     foo = "changed to string";
174     bar = 42;
175     WAIT_FOR_INPUT()
176     PRINT_NAMED(foo)
177     PRINT_NAMED(bar)
178     return 0;
179 }
180
(program exited with code: 0)
Press return to continue

Status g++-4.7 -O2 -std=c++0x -o "01_01_chameleon_type" "01_01_chameleon_type.cpp" (in directory: /home/msk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal
line: 171 / 180 col: 29 sel: 25 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```



```
01_02_general...an_template.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt..._demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Deskt...tivation
  02_01...ay.cpp
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  03_02...nly.cpp
~/Deskt...an_trait
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  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Deskt...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Deskt...pitfalls
  06_01...es.cpp
~/Deskt...graming

168 }
169
170 // +-----+
171 // |                                     main                               |
172 // +-----+
173 int main(int argc, char* argv[]) {
174     CLR_SCR()
175     PRINT_CYAN("press enter to continue")
176
177     WAIT_FOR_INPUT() //just hit the enter key to continue
178     PRINT_NAMED(mean(1, 2))
179
180     WAIT_FOR_INPUT()
181     PRINT_NAMED(mean(1u, 2u))
182
183     WAIT_FOR_INPUT()
184     PRINT_NAMED(mean(1.8, 2.0))
185
186     WAIT_FOR_INPUT()
187     PRINT_NAMED(mean(1ul, 2u))
188
189     WAIT_FOR_INPUT()
190     PRINT_NAMED(mean(1.8l, 2))
191
192     WAIT_FOR_INPUT()
193     PRINT_NAMED(mean(1.8, 2.0l))
194
195     WAIT_FOR_INPUT()
196     PRINT_NAMED(mean(1.8f, 2.0f))

Status g++-4.7 -O2 -std=c++0x -o "01_01_chameleon_type" "01_01_chameleon_type.cpp" (in directory: /home/msk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 178 / 209 col: 26 sel: 10 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```

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  introdu...on.cpp
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~/Deskt...graming

122     typedef double type;
123 };
124
125 //----- super mean trait -----
126 template<typename T, typename U>
127 struct super_mean_trait {
128     typedef typename mean_trait_chooser<T, U, helper_2<T, U>::value>::type type;
129 };
130
131 //----- super mean template -----
132 template<typename T, typename U>
133 inline typename super_mean_trait<T, U>::type mean(T const & a, U const & b) {
134     typedef typename super_mean_trait<T, U>::type return_type;
135     PRINT_BLUE("mean was called with types " << TYPE(T) << " and " << TYPE(U) <<
136     PRINT_GREEN("The return type is " << TYPE(return_type))
137     return (a + b) / 2.0;
138 }
139
140 //===== my_type =====
141 //----- has "asymetic" double addition -----
142 struct my_double {
143     my_double(): data(0) {
144     }
145     my_double(double const & in): data(in) {
146     }
147     double data;
148 };
149 //----- my_double + my_double -----
150 inline my_double operator+(my_double const & c, my_double const & d) {

```

Status g++-4.7 -O2 -std=c++0x -o "01_01_chameleon_type" "01_01_chameleon_type.cpp" (in directory: /home/msk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 133 / 209 col: 44 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: unknown


```
Terminal 13:45:07
press enter to continue
182 PRINT_NAMED(mean(1u, 2u))
183 WAIT_FOR_INPUT()
184 PRINT_NAMED(mean(1.8, 2.0))
mean was called with types i and i.
The return type is d
185 WAIT_FOR_INPUT()
186 PRINT_NAMED(mean(1u, 2u))
mean(1, 2) = 1.5
187 WAIT_FOR_INPUT()
188 PRINT_NAMED(mean(1u, 2u))
189 WAIT_FOR_INPUT()
190 PRINT_NAMED(mean(1.8, 2.0))
mean was called with types j and j.
The return type is d
191 WAIT_FOR_INPUT()
192 PRINT_NAMED(mean(1u, 2u))
mean(1u, 2u) = 1.5
193 PRINT_NAMED(mean(1.8, 2.0))
194 WAIT_FOR_INPUT()
195 PRINT_NAMED(mean(1.8f, 2.0f))
196 WAIT_FOR_INPUT()
197 PRINT_NAMED(mean(my_double(1), my_double(2)))
198 WAIT_FOR_INPUT()
199 PRINT_NAMED(mean(my_double(1), my_double(2)))
200 //~ WAIT_FOR_INPUT()
201 //~ PRINT_NAMED(mean(2.0, my_double(1)))
202 //~ WAIT_FOR_INPUT()
203 //~ PRINT_NAMED(mean(my_double(1), 2.0))
204
205 return 0;
206 }
207
208
209

Status g++-4.7 -O2 -std=c++0x -o "01_02_general_mean_template" "01_02_general_mean_template.cpp" (in direct
Compiler Compilation finished successfully.
Messages
Scribble
Terminal
line: 208 / 209 col: 1 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```



```
01_03_random_generator.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk..._demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Desk...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Desk...e_basics
  03_03_...on.cpp
~/Desk..._classes
  03_01_...er.hpp
  03_01_...impl.cpp
  03_01_...es.cpp
~/Desk...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Desk...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Desk...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Desk...pitfalls
  06_01_...es.cpp
~/Desk...gramina

156     }
157     };
158
159     typename RNG::type rng; ///< the native rng
160     T scale;    ///< length of the range
161     T offset;  ///< start of the range
162     const short int shift; ///< shows, what operations are needed (for speed
163     uint64_t seed_; ///< the used seed
164 };
165 // +-----+
166 // |                               |
167 // +-----+
168 int main(int argc, char* argv[]) {
169     CLR_SCR();
170
171     random_class<double      , fibonacci>    rng1(0, 1);
172     random_class<int        , mersenne>     rng2(1, 6);
173     random_class<unsigned long int, mersenne_fast> rng3(0, 1000000l);
174
175     for(uint i = 0; i < 3; ++i)
176         PRINT_RED(rng1())
177     for(uint i = 0; i < 3; ++i)
178         PRINT_YELLOW(rng2())
179     for(uint i = 0; i < 3; ++i)
180         PRINT_GREEN(rng3())
181
182     return 0;
183 }
184
```

Status **g++-4.7 -O2 -std=c++0x -o "01_02_general_mean_template" "01_02_general_mean_template.cpp" (in direct**
Compiler **Compilation finished successfully.**
Messages
Scribble
Terminal

line: 171 / 184 col: 46 sel: 42 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main

```
01_04_runtime_prime.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk..._demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Desk...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Desk...e_basics
  03_03...on.cpp
~/Desk...classes
  03_01...er.hpp
  03_01...impl.cpp
  03_01...es.cpp
~/Desk...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Desk...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Desk...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Desk...pitfalls
  06_01...es.cpp
~/Desk...gramina

30         return false;
31     }
32     return true;
33 }
34
35 // +-----+
36 // |                                     main |
37 // +-----+
38 int main(int argc, char* argv[]) {
39     CLR_SCR()
40     PRINT_CYAN("press enter to continue")
41
42     //~ int const n = 10;
43     int const n = 100;
44
45     int res = 0;
46     for(int i = n; i > 2; --i) {
47         if(is_prime(i)) {
48             res = i;
49             break;
50         }
51         WAIT_FOR_INPUT() //just hit the enter key to continue
52         PRINT_RED(i << " is not prime")
53     }
54     WAIT_FOR_INPUT()
55     PRINT_GREEN(res << " is the biggest prime <= " << n)
56     return 0;
57 }
58
```

Status g++-4.7 -O2 -std=c++0x -o "01_03_random_generator" "01_03_random_generator.cpp" (in directory: /home/
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 57 / 58 col: 1 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main


```
Terminal 13:55:40
press enter to continue
return false;
31 }
32 return true;
33 }
100 is not prime
01_03_tor.cpp 35 // +-----+
01_04_me.cpp 36 // | main |
01_05_me.cpp 37 // +-----+
01_06_pl.cpp 38 int main(int argc, char* argv[]) {
02_02_ay.cpp 39 CLR_SCR()
02_03_ay.cpp 40 PRINT_CYAN("press enter to continue")
03_03_on.cpp 41 //~ int const n = 10;
~/Desktop/classes 42 int const n = 100;
03_01_er.hpp 43
03_01_me.cpp 44
03_01_es.cpp 45 -----int res = 0;
(program exited with code: 0)
Press return to continue
03_02_nly.cpp 46 while (i > 2; --i) {
~/Desktop/an_trait 47 if (!is_prime(i)) {
04_01_ns.cpp 48 res = i;
04_02_pt.cpp 49 break;
04_03_ait.cpp 50 }
04_04_ait.cpp 51 WAIT_FOR_INPUT() //just hit the enter key to continue
~/Desktop/5_sfinae 52 PRINT_RED(i << " is not prime")
05_01_ple.cpp 53 }
05_02_ss.cpp 54 WAIT_FOR_INPUT()
05_03_od.cpp 55 PRINT_GREEN(res << " is the biggest prime <= " << n)
05_04_its.cpp 56 return 0;
~/Desktop/pitfalls 57 }
06_01_es.cpp 58
~/Desktop/graminao

Status g++-4.7 -O2 -std=c++0x -o "01_04_runtime_prime" "01_04_runtime_prime.cpp" (in directory: /home/mzk/De
Compiler Compilation finished successfully.
Messages
Scribble
Terminal
line: 55 / 58 col: 4 sel: 52 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```

01_05_compile_time_prime.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany

```

57         , bool Cond
58         , typename Incr
59         , typename Body
60         , typename ResSoFar>
61 struct m_for_rec {
62     typedef typename m_for_rec<typename Incr::template apply<Index>::type
63         , Max
64         , greater<typename Incr::template apply<Index>::t
65     |
66         , Incr
67         , Body
68         , typename m_if<
69             Body::template apply<Index>::va
70         , Index
71         , ResSoFar
72     >::type type;
73 };
74
75 template< typename IndexI
76         , typename Max
77         , typename Incr
78         , typename Body
79         , typename ResSoFar>
80 struct m_for_rec<Index, Max, false, Incr, Body, ResSoFar> {
81     typedef ResSoFar type;
82 };
83
84 template< typename Init
85         , typename Max

```

Status **g++-4.7 -O2 -std=c++0x -o "01_05_compile_time_prime" "01_05_compile_time_prime.cpp" (in directory: /ho**

Compiler **01_05_compile_time_prime.cpp: In function 'void no_main()':**

Messages **01_05_compile_time_prime.cpp:120:5: error: 'foo' is not a member of 'result_type {aka m_int<97>}'**

Scribble **Compilation failed.**

Terminal

line: 65 / 122 col: 0 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: unknown


```

01_05_compile_time_prime.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Deskt...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Deskt...e_basics
  03_03...on.cpp
~/Deskt...classes
  03_01...er.hpp
  03_01_impl.cpp
  03_01...es.cpp
~/Deskt...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Deskt...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Deskt...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Deskt...pitfalls
  06_01...es.cpp
~/Deskt...gramina

194      template<typename U>
195      struct apply{
196          enum{value = !bool(mod<T, U>::type::value)};
197      };
198  };
199
200  struct m_is_prime {
201      template<typename T>
202      struct apply {
203          typedef typename m_for<m_int<2>, T, increment, divisible<T> >::type type;
204          enum{value = (2 == type::value)};
205      };
206  };
207  // +-----+
208  // |                                     "main" |
209  // +-----+
210  void no_main() { //;-)
211  | //~ int const n = 10;
212  | int const n = 100; I
213
214  //not optimal since it goes from 2 to n instead of going from n to 0
215  typedef typename m_for<m_int<2>
216  |     , m_int<n>
217  |     , increment
218  |     , m_is_prime>::type result_type;
219
220  | result_type::foo; //for a compiletime error
221  }
222

```

Status g++-4.7 -O2 -std=c++0x -o "01_05_compile_time_prime" "01_05_compile_time_prime.cpp" (in directory: /home/msk/Desktop/ProgTechFinal/01_demos)

Compiler 01_05_compile_time_prime.cpp: In function 'void no_main()':

Messages 01_05_compile_time_prime.cpp:120:5: error: 'foo' is not a member of 'result_type {aka m_int<97>}'

Scribble Compilation failed.

Terminal

line: 111 / 122 col: 0 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: no_main

```

01_06_compile_time_prime_mpl.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk..._demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Desk...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Desk...e_basics
  03_03_...on.cpp
~/Desk..._classes
  03_01_...er.hpp
  03_01_...impl.cpp
  03_01_...es.cpp
~/Desk...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Desk...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Desk...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Desk...pitfalls
  06_01_...es.cpp
~/Desk...gramina

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, and_< greater<_1, index>
, equal_to<modulus<_1, index>, int_<
>
>::type
, greater<end, incr>::value
, incr
, end
>::type type;
};
template<typename seq, typename index, typename end>
struct remove_non_prim<seq, false, index, end> {
  typedef seq type;
};
// -----+
// | main |
// -----+
int main(int argc, char* argv[]) {
  int const n = 10;
  //~ int const n = 100;

  typedef vector_c<int> v0;
  typedef typename insert_range<v0, end<v0>::type, range_c<int, 2, n> >::type ra
  typedef typename remove_non_prim<range, true, int_<2>, int_<n> >::type prime_v
  typedef int_<back<prime_vec>::type::value> result_type;

  result_type::foo; //for a compiletime error
  return 0;
}

```

Status `g++-4.7 -O2 -std=c++0x -o "01_06_compile_time_prime_mpl" "01_06_compile_time_prime_mpl.cpp" (in dire`

Compiler

Messages

Scribble

Terminal

line: 48 / 59 col: 21 sel: 0 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main


```

01_06_compile_time_prime_mpl.cpp - /home/msk/Desktop/ProgTechFinal/01_demos - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk...demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Desk...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Desk...e_basics
  03_03_...on.cpp
~/Desk...classes
  03_01_...er.hpp
  03_01_...impl.cpp
  03_01_...es.cpp
~/Desk...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Desk...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Desk...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Desk...pitfalls
  06_01_...es.cpp
~/Desk...gramina

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, and_< greater<_1, index>
, equal_to<modulus<_1, index>, int_<
>
>::type
, greater<end, incr>::value
, incr
, end
>::type type;
};
template<typename seq, typename index, typename end>
struct remove_non_prim<seq, false, index, end> {
  typedef seq type;
};
// -----+
// | main |
// -----+
int main(int argc, char* argv[]) {
  //~ int const n = 10;
  int const n = 100;

  typedef vector_c<int> v0;
  typedef typename insert_range<v0, end<v0>::type, range_c<int, 2, n> >::type range_c;
  typedef typename remove_non_prim<range, true, int_<2>, int_<n> >::type prime_vec;
  typedef int_<back<prime_vec>::type::value> result_type;

  result_type::foo; //for a compiletime error
  return 0;
}

```

Status	g++-4.7 -O2 -std=c++0x -o "01_06_compile_time_prime_mpl" "01_06_compile_time_prime_mpl.cpp" (in dire
Compiler	01_06_compile_time_prime_mpl.cpp: In function 'int main(int, char**)':
Messages	01_06_compile_time_prime_mpl.cpp:56:5: error: 'foo' is not a member of 'result_type {aka mpl::int_<97>}'
Scribble	Compilation failed.
Terminal	

line: 58 / 59 col: 1 sel: 1 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main

```
02_02_better_way.cpp - /home/msk/Desktop/ProgTechFinal/02_template_motivation - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Deskt...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Deskt...e_basics
  03_03_...on.cpp
~/Deskt...classes
  03_01_...er.hpp
  03_01_impl.cpp
  03_01_...es.cpp
~/Deskt...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Deskt...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Deskt...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Deskt...pitfalls
  06_01_...es.cpp
~/Deskt...graming

29 //class, bool, integer-types, fct-ptr are ok
30 //float types like double are not accepted
31
32 template<typename T, int N>
33 class template_class {
34 public:
35     T & operator[](int const & index) {
36         assert(index >= 0 and index < N);
37         return array_[index];
38     }
39 private:
40     T array_[N];
41 };
42
43 // +-----+
44 // |                               main                               |
45 // +-----+
46 int main(int argc, char* argv[]) {
47     //NEEDS -std=c++0x for uint
48     //just typedef unsigned int uint; to get rid of it
49     CLR_SCR()
50     PRINT_CYAN("press enter to continue")
51
52     WAIT_FOR_INPUT() //just hit the enter key to continue
53     //double_5_class d5;
54     template_class<double, 5> d5;
55
56     for(uint i = 0; i < 5; ++i)
57         d5[i] = i + 0.1;

```

Status g++-4.7 -O2 -std=c++0x -o "02_01_wrong_way" "02_01_wrong_way.cpp" (in directory: /home/msk/Desktop/P/)
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 41 / 88 col: 2 sel: 206 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: unknown


```
*02_02_better_way.cpp - /home/msk/Desktop/ProgTechFinal/02_template_motivation - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Deskt...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Deskt...e_basics
  03_03_...on.cpp
~/Deskt...classes
  03_01_...er.hpp
  03_01_impl.cpp
  03_01_...es.cpp
~/Deskt...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Deskt...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Deskt...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Deskt...pitfalls
  06_01_...es.cpp
~/Deskt...gramina

32 template<typename T, int N>
33 class template_class {
34 public:
35     T & operator[](int const & index) {
36         assert(index >= 0 and index < N);
37         return array_[index];
38     }
39 private:
40     T array_[N];
41 };
42
43 // +-----+
44 // |                                     main                               |
45 // +-----+
46 int main(int argc, char* argv[]) {
47     //NEEDS -std=c++0x for uint
48     //just typedef unsigned int uint; to get rid of it
49     CLR_SCR()
50     PRINT_CYAN("press enter to continue")
51
52     WAIT_FOR_INPUT() //just hit the enter key to continue
53     //double_5_class d5;
54     template_class<double, 5> d5;
55
56     for(uint i = 0; i < 5; ++i)
57         d5[i] = i + 0.1;
58
59     for(uint i = 0; i < 5; ++i)
60         PRINT_RED("d5[" << i << "] = " << d5[i])

Status g++-4.7 -O2 -std=c++0x -o "02_01_wrong_way" "02_01_wrong_way.cpp" (in directory: /home/msk/Desktop/P
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 58 / 88 col: 0 sel: 0 INS SP MOD mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```

```
*02_03_template_way.cpp - /home/msk/Desktop/ProgTechFinal/02_template_motivation - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Deskt...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Deskt...e_basics
  03_03...on.cpp
~/Deskt...classes
  03_01...er.hpp
  03_01_impl.cpp
  03_01...es.cpp
~/Deskt...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Deskt...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Deskt...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Deskt...pitfalls
  06_01...es.cpp
~/Deskt...graming

18 #define PRINT_YELLOW(x) std::cout << "\033[1;33m" << x << "\033[0m" << std::endl;
19 #define PRINT_MAGENTA(x) std::cout << "\033[1;35m" << x << "\033[0m" << std::endl;
20 //all the \033... cmd are bash specific. See http://www.cplusplus.com/forum/unices
21
22 //===== includes =====
23 #include <iostream>
24 #include <assert.h> //use asserts! It will make your debugging way easier
25 //and it doesn't cut into the performance (-DNDEBUG)
26
27 //===== template class =====
28 template<typename T, int N>
29 class template_class {
30     //~ static_assert(N%5==0, "template_class must fulfil N%5==0");
31     //~ only checked during compiletime. Doesn't really matter where you put this
32 public:
33     typedef int size_type; //use typedefs to make later changes easy
34     T & operator[](size_type const & index) {
35         assert(index >= 0 and index < N);
36         return array_[index];
37     }
38     size_type size() const { //can also be done as a static, but is inlined anyway
39         return N;
40     }
41 private:
42     T array_[N];
43 };
44
45 d5[1.234]
46
```

Status g++-4.7 -O2 -std=c++0x -o "02_03_template_way" "02_03_template_way.cpp" (in directory: /home/msk/Desk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 43 / 87 col: 2 sel: 0 INS SP MOD mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: unknown


```
02_03_template_way.cpp - /home/msk/Desktop/ProgTechFinal/02_template_motivation - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Deskt...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Deskt...e_basics
  03_03...on.cpp
~/Deskt...classes
  03_01...er.hpp
  03_01_impl.cpp
  03_01...es.cpp
~/Deskt...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Deskt...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Deskt...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Deskt...pitfalls
  06_01...es.cpp
~/Deskt...graming

20 //all the \033... cmd are bash specific. See http://www.cplusplus.com/forum/unices
21
22 //===== includes =====
23 #include <iostream>
24 #include <assert.h> //use asserts! It will make your debugging way easier
25 //and it doesn't cut into the performance (-DNDEBUG)
26
27 //===== template class =====
28 template<typename T, int N>
29 class template_class {
30     static_assert(N%5==0, "template_class must fulfil N%5==0");
31     //only checked during compiletime. Doesn't really matter where you put this
32 public:
33     typedef int size_type; //use typedefs to make later changes easy
34     T & operator[](size_type const & index) {
35         assert(index >= 0 and index < N);
36         return array_[index];
37     }
38     size_type size() const { //can also be done as a static, but is inlined anyway
39         return N;
40     }
41 private:
42     T array_[N];
43 };
44
45 //===== template function =====
46 template<typename T>
47 inline void init_and_print(T & t) {
48     for(typename T::size_type i = 0; i < t.size(); ++i)
```

Status g++-4.7 -O2 -std=c++0x -o "02_03_template_way" "02_03_template_way.cpp" (in directory: /home/msk/Desk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 48 / 85 col: 17 sel: 12 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: init_and_print

```
*02_03_template_way.cpp - /home/msk/Desktop/ProgTechFinal/02_template_motivation - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk...demos
  01_01...pe.cpp
  01_02...te.cpp
  01_03...tor.cpp
  01_04...me.cpp
  01_05...me.cpp
  01_06...pl.cpp
~/Desk...tivation
  02_01...ay.cpp
  02_02...ay.cpp
  02_03...ay.cpp
~/Desk...e_basics
  03_03...on.cpp
~/Desk...classes
  03_01...er.hpp
  03_01_impl.cpp
  03_01...es.cpp
~/Desk...der_only
  03_02...er.hpp
  03_02...nly.cpp
~/Desk...an_trait
  04_01...ns.cpp
  04_02...pt.cpp
  04_03...ait.cpp
  04_04...ait.cpp
~/Desk...5_sfinae
  05_01...ple.cpp
  05_02...ss.cpp
  05_03...od.cpp
  05_04...its.cpp
~/Desk...pitfalls
  06_01...es.cpp
~/Desk...graming

58 // for(uint i = 0; i < t.size(); ++i)...
59 //...but it is generic. If size_type is changed to double this will still work
60 }
61
62
63 // +-----+
64 // |                main                |
65 // +-----+
66 int main(int argc, char* argv[]) {
67 //NEEDS -std=c++0x for uint
68 //just typedef unsigned int uint; to get rid of it
69 CLR_SCR()
70 PRINT_CYAN("press enter to continue")
71
72 WAIT_FOR_INPUT() //just hit the enter key to continue
73 template_class<double, 5> d5;
74 init_and_print<>(d5);
75
76 WAIT_FOR_INPUT()
77 template_class<double, 10> d10;
78 init_and_print(d10);
79
80 WAIT_FOR_INPUT()
81 template_class<int, 10> i10;
82 init_and_print(i10);
83
84 return 0;
85 }
86

Status g++-4.7 -O2 -std=c++0x -o "02_03_template_way" "02_03_template_way.cpp" (in directory: /home/msk/Desk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 74 / 86 col: 4 sel: 0 INS SP MOD mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```



```
*03_03_type_deduction.cpp - /home/msk/Desktop/ProgTechFinal/03_template_basics - Geany
Documents Files
~/Deskt...echFinal
  introdu...on.cpp
~/Deskt...demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Deskt...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Deskt...e_basics
  03_03_...on.cpp
~/Deskt...classes
  03_01_...er.hpp
  03_01_impl.cpp
  03_01_...es.cpp
~/Deskt...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Deskt...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Deskt...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Deskt...pitfalls
  06_01_...es.cpp
~/Deskt...gramina

42 template<typename T>
43 void print_no_deduce(int const & t) {
44     PRINT_GREEN("T = " << TYPE(T) << ", val = " << t)
45 }
46 // +-----+
47 // |                               main                               |
48 // +-----+
49 int main(int argc, char* argv[]) {
50     CLR_SCR()
51     PRINT_CYAN("press enter to continue")
52
53     my_template<int> t; //<int> is mandatory. the compiler has no chance guess the
54
55     WAIT_FOR_INPUT() //just hit the enter key to continue
56     PRINT_CALL(print_deduce(1.5)) //type deduction works 1.5 is int -> T = double
57     |
58     WAIT_FOR_INPUT()
59     PRINT_CALL(print_deduce<int>(1.5)); //is also fine, but 1.5 will be converted
60
61     //~ PRINT_CALL(print_no_deduce(1.5)) //doesn't work since the compiler cannot
62     WAIT_FOR_INPUT()
63     PRINT_CALL(print_no_deduce<double>(1.5))
64
65     WAIT_FOR_INPUT()
66     PRINT_CALL(t.print(1.5))
67
68     WAIT_FOR_INPUT()
69     PRINT_CALL(t.print(1))
70

Status g++-4.7 -O2 -std=c++0x -o "02_03_template_way" "02_03_template_way.cpp" (in directory: /home/msk/Desk
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 57 / 89 col: 4 sel: 0 INS SP MOD mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```

```
*03_03_type_deduction.cpp - /home/msk/Desktop/ProgTechFinal/03_template_basics - Geany
Documents Files
~/Desk...echFinal
  introdu...on.cpp
~/Desk..._demos
  01_01_...pe.cpp
  01_02_...te.cpp
  01_03_...tor.cpp
  01_04_...me.cpp
  01_05_...me.cpp
  01_06_...pl.cpp
~/Desk...tivation
  02_01_...ay.cpp
  02_02_...ay.cpp
  02_03_...ay.cpp
~/Desk...e_basics
  03_03_...on.cpp
~/Desk...classes
  03_01_...er.hpp
  03_01_...impl.cpp
  03_01_...es.cpp
~/Desk...der_only
  03_02_...er.hpp
  03_02_...nly.cpp
~/Desk...an_trait
  04_01_...ns.cpp
  04_02_...pt.cpp
  04_03_...ait.cpp
  04_04_...ait.cpp
~/Desk...5_sfinae
  05_01_...ple.cpp
  05_02_...ss.cpp
  05_03_...od.cpp
  05_04_...its.cpp
~/Desk...pitfalls
  06_01_...es.cpp
~/Desk...gramina

42 template<typename T>
43 void print_no_deduce(int const & t) {
44     PRINT_GREEN("T = " << TYPE(T) << ", val = " << t)
45 }
46 // +-----+
47 // |                               |
48 // +-----+
49 int main(int argc, char* argv[]) {
50     CLR_SCR()
51     PRINT_CYAN("press enter to continue")
52
53     my_template<int> t; //<int> is mandatory. the compiler has no chance guess the
54
55     WAIT_FOR_INPUT() //just hit the enter key to continue
56     PRINT_CALL(print_deduce(1.5)) //type deduction works 1.5 is int -> T = double
57
58     m_class m;
59     print_deduce(m) //(|
60
61
62     WAIT_FOR_INPUT()
63     PRINT_CALL(print_deduce<int>(1.5)); //is also fine, but 1.5 will be converted
64
65     //~ PRINT_CALL(print_no_deduce(1.5)) //doesn't work since the compiler cannot
66     WAIT_FOR_INPUT()
67     PRINT_CALL(print_no_deduce<double>(1.5))
68
69     WAIT_FOR_INPUT()
70     PRINT_CALL(t.print(1.5))

Status g++-4.7 -O2 -std=c++0x -o "02_03_template_way" "02_03_template_way.
Compiler Compilation finished successfully.
Messages
Scribble
Terminal

line: 59 / 93 col: 22 sel: 0 INS SP MOD mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```




```
Terminal 14:44:49
Documents Files
content
1: demonstration/polymorphism
2: template motivation
3: template basics
4: mean trait
5: central mechanism: SFINAE
64 CLR_SCR()
65 WAIT_FOR_INPUT()
66 PRINT_YELLOW(" majority of the examples works without c++0x")
67 WAIT_FOR_INPUT()
68 PRINT_YELLOW(" those few examples that need c++0x can also be realised with
69 WAIT_FOR_INPUT()
70 PRINT_YELLOW(" all examples are available on GitHub")
71 PRINT_YELLOW(" https://github.com/mskoenz/cpp\_template\_examples")
72 WAIT_FOR_INPUT()
73 PRINT_RED(" ask questions if you don't get something!")
74
75 return 42;
76 }
77

Status g++-4.7 -O2 -std=c++0x -o "introduction" "introduction.cpp" (in directory: /home/msk/Desktop/ProgTechFinal
Compiler Compilation finished successfully.
Messages
Scribble
Terminal
line: 71 / 77 col: 68 sel: 48 INS SP mode: Unix (LF) encoding: UTF-8 filetype: C++ scope: main
```