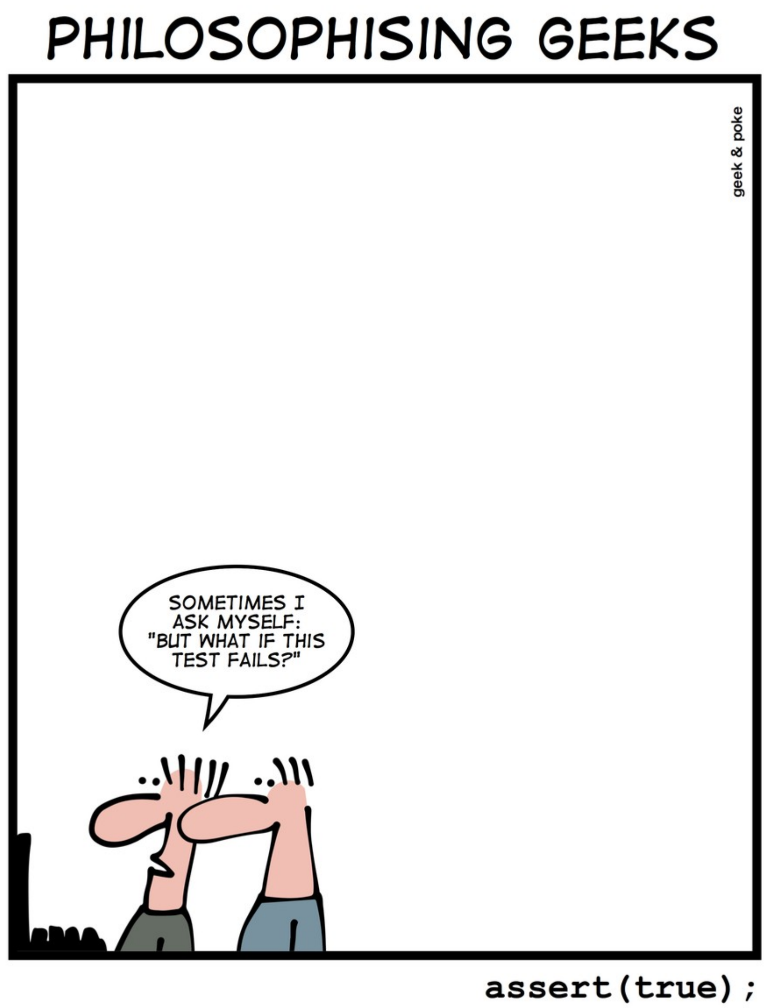
C++ Quiz



Krishna Kumar

Fun with Type Deduction

- const int cx = 0;
- auto cx2 = cx;
- decltype(cx) cx3 = cx;
- template <typename T>

  void f1(T param);

  f1(cx);
- template <typename T>

  void f1(T& param);

  f1(cx);
- template <typename T>

  void f1(T&& param);

  f1(cx);

- Type? Why? //Type is int
- Type? Why? // Const int
- T's type and why?

  param is a copy of cx – int
- T's type and why?

  Referring to a chunk of memory – const int
- T's type and why?

  Neat trick to allow argument forwarding – perfect forwarding

  const int&

Fun with Type Deduction: Solution

- const int cx = 0;
- auto cx2 = cx;
- decltype(cx) cx3 = cx;
- template <typename T>

  void f1(T param);

  f1(cx);
- template <typename T>

  void f1(T& param);

  f1(cx);
- template <typename T>

  void f1(T&& param);

  f1(cx);

- //Type is int
- // Const int
- T's type and why?
- T's type and why?
- T's type and why?

Lambda expressions - Type

- const int cx = 0;
- auto lam = [cx] {cx = 10;};
- // Compiler generated class
- class UptoCompiler {
  - private:
    - ??? cx;
- };

- // What happens here?
- // type? Why?

Lambda expressions: Solution

- const int cx = 0;
- auto lam = [cx] {cx = 10;};
- // Compiler generated class
- class UptoCompiler {
  - private:
    - ??? cx;
- };

- // Error! Why?
- // const int
- The variable cx within {} is what is in the compiler generated class.
- To preserve what is being passed to the hidden compiler generated class.
- Programming in 2 scopes!

Lambda init capture: C++14

- const int cx = 0;
- auto lam = [cx = cx] {cx = 10;};
- // Compiler generated class
- class UptoCompiler {
  - private:

    ??? cx;
  - Public:

    void operator()() const

    { cx = 0; }

    ...
- };

- //Error why?
- // type? Why?
-
-

Lambda init capture: Solution

- const int cx = 0;
- auto lam = [cx = cx] {cx = 10;};
- // Compiler generated class
- class UptoCompiler {
  - private:

    ??? cx;
  - Public:

    void operator()() const

    { cx = 0; }

    ...
- };

- // Error! Why?
- // int (acts like a const int!)
-

Lambda init capture: mutable

- const int cx = 0;
- auto lam = [cx = cx] mutable {cx = 10;};
- auto lam = [cx = cx] ()mutable {cx = 10;};
- class UptoCompiler {
  - private:

    ??? cx;
  - Public:

    void operator()() const

    { cx = 0; }

    ...
- };

- //Error why?
- // Standard failed to add empty() for mutable!
-
- Type??
- Int (acts like an int)! Phew!

Type deduction

For const int cx = 0;

Context	Type
auto	int
decltype	const int
template (T param)	int
template (T& param)	const int
template (T&& param)	const int&
lambda (by-value capture)	const int
lambda (init capture) - same as auto!	int

Type deduction & initialisation

- int x1 = 0;

  int x2(0);

  int x3 = {0};

  int x4 {0};
- auto x1 = 0;

  auto x2(0);

  auto x3 = {0};

  auto x4 {0};
- template<typename T>

  void f(T param)

  f({0});

- // type? Why? - int
- // type? Why? - int
- // type? initializer_list<int>
- // type? initializer_list<int>
- // type? Why?

  Error!

  No type “{0}”

Type deduction: decltype

- struct Point {

      int x, y;

  };
- Type of Point::x? - int
- Point p;

  const Point& cp = p';
- What is the type cp.x?
- Both
  - int
  - const int

- C++ solution

  decltype(cp.x) ~ int

  decltype((cp.x)) ~ const int&

auto to explicit type deduction

std::map<std::string, int> m;

- // Why this is inefficient

for (const std::pair<std::string, int>& p : m) …

- // This is optimised

for (const auto& p : m) ….

auto or explicit type deduction: solution

- Avoid accidental temporary creation!

  std::map<std::string, int> m;

- // Holds object of type std::pair<**const** std::string, int>
- // Why this is inefficient
- // creates a temp on each iteration std::string is copied

  for (const std::pair<std::string, int>& p : m) …

- // This is optimised
- // No temporaries are created

  for (const auto& p : m) ….

Templates & function calls

```
1)  template<typename T1, typename T2>
    void f( T1, T2 );

2)  template<typename T> void f( T );

3)  template<typename T> void f( T, T );

4)  template<typename T> void f( T* );

5)  template<typename T> void f( T*, T );

6)  template<typename T> void f( T, T* );

7)  template<typename T> void f( int, T* );

8)  template<> void f<int>( int );

9)  void f( int, double );

10) void f( int );
```

- int i; double d;
- float ff; complex<double> c;
- **non-templates are always preferred over templates**

```
a) f( i );          // invokes?
b) f<int>( i );     // invokes?
c) f( i, i );       // invokes?
d) f( c );          // invokes?
e) f( i, ff );      // invokes?
f) f( i, d );       // invokes?
g) f( c, &c );      // invokes?
h) f( i, &d );      // invokes?
i) f( &d, d );      // invokes?
j) f( &d );         // invokes?
k) f( d, &i );      // invokes?
l) f( &i, &i );     // invokes?
```

Templates & function calls

1) template<typename T1, typename T2> void f(T1, T2);

2) template<typename T> void f(T);

3) template<typename T> void f(T, T);

4) template<typename T> void f(T*);

5) template<typename T> void f(T*, T);

6) template<typename T> void f(T, T*);

7) template<typename T> void f(int, T*);

8) template<> void f<int>(int);

9) void f(int, double);

10) void f(int);

- int i; double d;
- float ff; complex<double> c;

a) f(i); // 10

b) f<int>(i); // 8 – f<int> explicit

c) f(i, i); // 3

d) f(c); // 2

e) f(i, ff); // 1 why not 9? only exact match; ff is float not double.

f) f(i, d); // 9

g) f(c, &c); // 6

h) f(i, &d); // 7

i) f(&d, d); // 5

j) f(&d); // 4

k) f(d, &i); // 1

l) f(&i, &i); // 3

Templates & function calls

- **// What is the output of this program?**
- template <class T> void f(T &i) { std::cout << 1; }
- template <> void f(const int &i) { std::cout << 2; }
- int main() {
  - int i = 42;
  - f(i);
- }

Templates & function calls: Solution

- **// What is the output of this program?**
- template <class T> void f(T &i) { std::cout << 1; }
- template <> void f(const int &i) { std::cout << 2; }
- int main() {
  - int i = 42;
  - f(i);
- }
- Solution: 1
- The templated function will be instantiated as void f(int&), which is a better match than f(const int&).

Templates & function calls II

- template <int i>

  void fun() {
  - i = 20;
  - std::cout << i;
- }
- int main() {
  - fun<10>();

  }

- Result:
- Compiler error in line "i = 20;"
- Non-type parameters must be const, so they cannot be modified.
- Compiler error: lvalue required as left operand of assignment i = 20;

Inheritance - should this compile?

- class Base {
  - public:
    void dobasework();
- };
- class Derived : public Base{
  - public:
    void derivedwork() {
      dobasework();
    }
- };

- template <typename T>
- class Base {
  - public:
    void dobasework();
- };
- template <typename T>
- class Derived : public Base<T>{
  - public:
    void derivedwork() {
      dobasework();
    }
- };
- Dependent base class
- Two-phase lookup

Inheritance - specilaisation

- template <typename T>
- class Base {
  - public:

    void dobasework();
- };
- template <typename T>
- class Derived : public Base<T>{
  - public:

    void derivedwork() {

      dobasework();

    }
- };
- // cont...

- // cont…
- // Possible future
- // no base work

  template<>

  class Base<int> {};
- // Fail!

  Derived<int> d;

  do.derivedWork();

Inheritance – specilaisation: solution?

- template <typename T>
- class Base {
  - public:

    void dobasework();
- };
- template <typename T>
- class Derived : public Base<T>{
  - public:

    void derivedwork() {

    Base<T>::dobasework();

    }
- };
- // Base<T>:: turns off virtual function calls – not relevant here

- template <typename T>
- class Base {
  - public:

    void dobasework();
- };
- template <typename T>
- class Derived : public Base<T>{
  - public:

    void derivedwork() {

    this->dobasework();

    }
- };
- // Lookup only in the current

Templates & Inheritance

- struct Base{

    int x;

    template <int Trange>

    virtual void print()   {

        std::cout << Trange + x + 1; }

  };
- struct Derived : public Base {
  - template <int Trange>

    void print()   {

        std::cout << Trange + x + 2; }
- };
- int main() {

    Base* p = new Derived;

    p->x = 1;

    p->print<5>();

  }
- // Result -Error code doesn't compile!
- // Member function template cannot be virtual

- struct Base{

    int x;

    template <int Trange>

    void print()   {

        std::cout << Trange + x + 1; }

  };
- struct Derived : public Base {
  - template <int Trange>

    void print()   {

        std::cout << Trange + x + 2; }
- };
- int main() {

    Base* p = new Derived;

    p->x = 1;

    p->print<5>();

  }
- // Result – Base class - 7
- // For Derived* - Derived - 8

Template specialisation

- template <class T>
- T max (T &a, T &b) {

    std::cout << "generic";

    return (a > b)? a : b;
- }
- template <>
- int max <int> (int &a, int &b) {
    - std::cout << "specialised";

    return (a > b)? a : b;
- }
- int main () {

    int a = 10, b = 20;

    std::cout << max <int> (a, b);
- }

- Which one will be called?
- Result:
    - Specialised 20
- This is an example of template specialization. Sometime we want a different behaviour of a function/class template for a particular data type. For this, we can create a specialized version for that particular data type.

Namespace – Output?

- namespace foo {

    void bar()   {

        x++;

    - std::cout << x;

  - }

    int x;

- }
- int main() {
  - foo:x = 0;
  - foo::bar();
- }

- namespace foo {
  - int x;
- }
- namespace foo {

    void bar()   {

        x++;

        std::cout << x;

  - }
- }
- int main() {
  - foo:x = 0;
  - foo::bar();
- }

Namespace – Solution

- namespace foo {

    void bar() {

        x++;

    - std::cout << x;
  - }

    int x;
- }
- int main() {
  - foo:x = 0;
  - foo::bar();
- }
- // Error: Names used in a namespace must be declared before before their use

- namespace foo {
  - int x;
- }
- namespace foo {

    void bar() {

        x++;

        std::cout << x;

  - }
- }
- int main() {
  - foo:x = 0;
  - foo::bar();
- }
- // Result: 1

ADL (Argument Dependent Lookup)

- Which of the following functions are found when called in main during name lookup?
- namespace standards {

  struct datastructure { };

  void foo(const datastructure& ds) { }

  void bar() {}
- }
- int main() {

  standards::datastructure ds;

  foo(ds);

  bar();
- }

Koenig or ADL : Solutioin

- namespace standards {

  struct datastructure { };

  void foo(const datastructure& ds) { }

  void bar() {}
- }
- int main() {

  standards::datastructure ds;

  foo(ds);

  bar();
- }

- // Result = foo();
- This is called koenig lookup or argument dependent name lookup. In this case, the namespace 'standards' is searched for a function 'foo' because its argument 'ds' is defined in that namespace. For function 'bar', no additional namespaces are searched and the name is not found.

Lvalue reference - I

- int& fun() {

    static int x = 10;

    return x;

- }
- int main() {

    fun() = 30;

    std::cout << fun();

- }

- Guess the output

(a) 10

(b) 30

(c) Compiler error

Lvalue reference – I (Solution)

- int& fun() {

  static int x = 10;

  return x;
- }
- int main() {

  fun() = 30;

  std::cout << fun();
- }

Result : 30

- When a function returns by reference, it can be used as lvalue.
- Since x is a static variable, it is shared among function calls and the initialization line "static int x = 10;" is executed only once. The function call fun() = 30, modifies x to 30. The next call "cout << fun()" returns the modified value.

Lvalue reference - II

- int& fun() {

    int x = 10;

    return x;
- }
- int main() {

    fun() = 30;

    std::cout << fun();
- }

- Guess the output

(a) 10

(b) 30

(c) Compiler error

Lvalue reference – II (Solution)

- int& fun() {

  int x = 10;

  return x;
- }
- int main() {

  fun() = 30;

  std::cout << fun();
- }

Result : 10

- When a function returns by reference, it can be used as lvalue.
- Since x is a local variable, every call to fun() will have use memory for x and call “fun() = 30" will not effect on next call.
- Or
- **Segmentation fault**
- warning: reference to local variable ‘x’ returned [-Wreturn-local-addr]

Rvalue reference – Output?

- Case I
- int main() {

    int x = int() = 3;

    std::cout << x;
- }
- **Output:**
  - **Compiler Error**
  - **Undefined**
  - **3**

- Case II
- int main() {

    int&& x = int();

    x = 3;

    std::cout << x;
- }
- **Output:**
  - **Compiler Error**
  - **Undefined**
  - **3**

Rvalue reference – Solution

- What is it output?
- int main() {

    int x = int() = 3;

    std::cout << x;
- }
- int() creates a temporary variable which is an rvalue. The temporary variable that is created can not be assigned to since it is an rvalue. Thus this code should not compile

- int main() {

    int&& x = int();

    x = 3;

    std::cout << x;
- }
- int() creates a temporary variable.
- int&& is a universal reference
- **Result: 3**

References

- Scott Meyers “The last thing D needs”
- Herb Sutter's Guru of the Week
- http://geeksquiz.com/c-plus-plus/
- http://www.mycppquiz.com/