CSE 333 – Section 4: C++ Intro

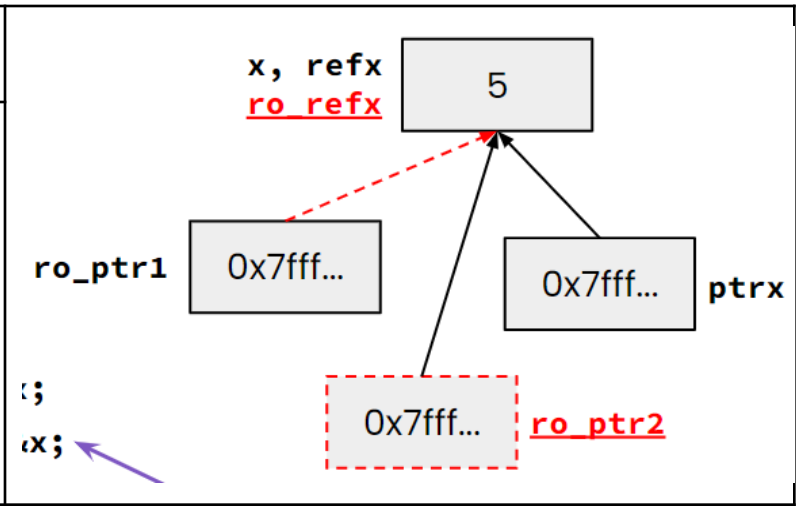
Const & References

1) Consider the following functions and variable declarations

a) Draw a memory diagram for the variables declared in `main`.

```
void foo(const int& arg);
void bar(int& arg);
```

```
int main(int argc, char **argv) {
  int x = 5;
  int& x_ref = x;
  int* x_ptr = &x;
  const int& ro_x_ref = x;
  const int* ro_ptr1 = &x;
  int* const ro_ptr2 = &x;
  // ...
}
```



b) When would you prefer `void func(int &arg);` to `void func(int *arg);`? Expand on this distinction for other types besides `int`.

- When you don't want to deal with pointer semantics, use references
- When you don't want to copy stuff over (doesn't create a copy, especially for parameters and/or return values), use references
- Style wise, we want to use **references for input parameters** and **pointers for output parameters**, with the output parameters declared last

c) What does the compiler think about the following lines of code:

```
bar(x_ref);                 // No issues
bar(ro_x_ref);              // Error - ro_x_ref is const
foo(x_ref);                 // No issues
```

d) How about this code?

```
ro_ptr1 = (int*) 0xDEADBEEF;        // No issues
x_ptr = &ro_x_ref;                  // Error - ro_x_ref is const
ro_ptr2 = ro_ptr2 + 2;              // Error - ro_ptr2 is const
*ro_ptr1 = *ro_ptr1 + 1;            // Error - (*ro_ptr1) is const
```

e) In a function `const int f(const int a);` are the `const` declarations useful to the client? How about the programmer? What about this function needs to change to make `const` matter?

The `const` return and parameter both don't affect the client at all, since they work with copies of the parameter/return value. This enforces the programmer not to modify `a` at all. If `f` used references for the parameter/return, then it would matter to both the client and the programmer.

2) Refer to the following poorly-written class declaration. (10 min)

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

 private:
  int  q_;     // question number
  char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

a) Indicate (**Y**/**N**) which *lines* of the snippets of code below (if any) would cause compiler errors:

Code Snippets	Error?
`const MultChoice m1(1,'A');`	N
`MultChoice m2(2,'B');`	N
`cout << m1.get_resp();`	Y
`cout << m2.get_q();`	N

Code Snippets	Error?
`const MultChoice m1(1,'A');`	N
`MultChoice m2(2,'B');`	N
`m1.Compare(m2);`	N
`m2.Compare(m1);`	Y

b) What would you change about the class declaration to make it better? Feel free to mark directly on the class declaration above if desired. **(optional)**
Many possibilities. Importantly, make get_resp() const and make the parameter to Compare() const. Stylistically, it makes sense to add a setter method and default constructor. Could also optionally disable copy constructor and assignment operator.

3. Refer to the following file definitions.

Point.h

```
class Point { … };
```

UsePoint.cc

```
#include "Point.h"
#include "Thing.h"
int main( … ) { … }
```

UseThing.cc

```
#include "Thing.h"
int main( … ) { … }
```

Point.cc

```
#include "Point.h"
// defs of methods
```

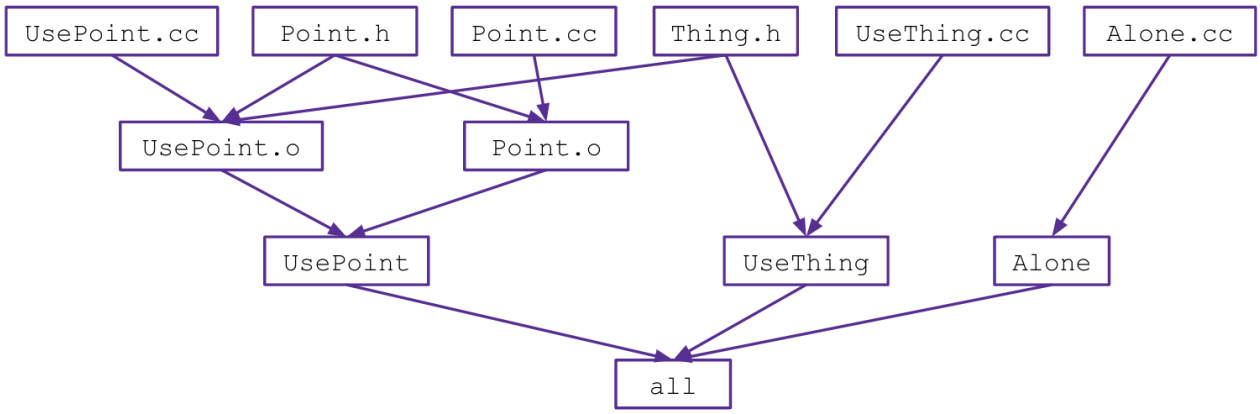
Thing.h

```
struct Thing { … };
// full struct def here
```

Alone.cc

```
int main( … ) { … }
```

a. Draw out Point's DAG
(The direction of the arrows is not important, but be consistent)



b. Write the corresponding Makefile for Point

```
CFLAGS = -Wall -g -std=c++17

all: UsePoint UseThing Alone

UsePoint: UsePoint.o Point.o
	g++ $(CFLAGS) -o UsePoint UsePoint.o Point.o

UsePoint.o: UsePoint.cc Point.h Thing.h
	g++ $(CFLAGS) -c UsePoint.cc

Point.o: Point.cc Point.h
	g++ $(CFLAGS) -c Point.cc

UseThing: UseThing.cc Thing.h
	g++ $(CFLAGS) -o UseThing UseThing.cc

Alone: Alone.cc
	g++ $(CFLAGS) -o Alone Alone.cc

clean:
	rm UsePoint UseThing Alone *.o *~
```

Bonus: Const Const Const

Which of the following lines will result in a compiler error?

Code Snippets	Error?
`int z = 5;`	N
`const int* x = &z;`	N
`int* y = &z;`	N
`x = y;`	N
`*x = *y;`	Y

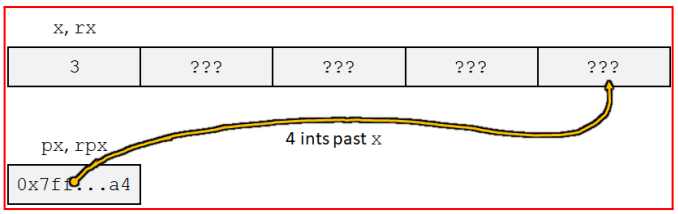
Code Snippets	Error?
`int z = 5;`	N
`int* const w = &z;`	N
`const int* const v = &z;`	N
`*v = *w;`	Y
`*w = *v;`	N

Bonus: What does the following program print out? Hint: box-and-arrow diagram!

```
int main(int argc, char** argv) {
  int x = 1;       // assume &x = 0x7ff...94
  int& rx = x;
  int* px = &x;
  int*& rpx = px;

    rx = 2;
  *rpx = 3;
   px += 4;

  cout << "   x: " <<    x << endl;  //   x: 3
  cout << "  rx: " <<   rx << endl;  //  rx: 3
  cout << " *px: " <<  *px << endl;  // *px: ??? (garbage)
  cout << "  &x: " <<   &x << endl;  //  &x: 0x7ff...94
  cout << " rpx: " <<  rpx << endl;  // rpx: 0x7ff...a4
  cout << "*rpx: " << *rpx << endl;  // *rpx = *px: ??? (garbage)
  return 0;
}
```



Bonus: Mystery Functions

Consider the following C++ code, which has **`___???___`** in the place of 3 function names in `main`:

```
struct Thing {
  int a;
  bool b;
};

void PrintThing(const Thing& t) {
  cout << boolalpha << "Thing:  " << t.a << ", " << t.b << endl;
}

int main() {
  Thing foo = {5, true};
  cout << "(0) ";
  PrintThing(foo);

  cout << "(1) ";
  ___???___(foo);   // mystery 1:  f2
  PrintThing(foo);

  cout << "(2) ";
  ___???___(&foo);  // mystery 2:  f3
  PrintThing(foo);

  cout << "(3) ";
  ___???___(foo);   // mystery 3:  f1, f2, f4, or f5
  PrintThing(foo);

  return 0;
}
```

Program Output:	**Possible Functions:**
(0) Thing: 5, true (1) Thing: 6, false (2) Thing: 3, true (3) Thing: 3, true	void **f1**(Thing t); void **f2**(Thing& t); void **f3**(Thing* t); void **f4**(const Thing& t); void **f5**(const Thing t);

List *all* of the possible functions (**`f1`** - **`f5`**) that could have been called at each of the three mystery points in the program that would compile cleanly (no errors) and could have produced the results shown. There is at least one possibility at each point; there might be more.

- Hint: look at parameter lists and types in the function declarations and in the calls.