CSE 333 – Section 4: C++ Intro
Welcome back to section! We’re glad that you’re here :) 

References
References create aliases that we can bind to existing variables. References are not separate variables and cannot be reassigned after they are initialized. In C++, you define a reference using: `type & name = var`. The `&` is similar to the `*` in a pointer definition in that it modifies the type and the space can come before or after it.

Const
Const makes a variable `unchangeable` after initialization, and is enforced at compile time.

```
const int x = 5; // Can’t assign to x
const int* x_ptr = &x; // Can assign to x_ptr, but not *x_ptr
int* const y_ptr = &y; // Can assign to *y_ptr, but not y_ptr
const int* const z_ptr = &z; // Can’t assign to *z_ptr or z_ptr
```

Class objects can be declared const too - a const class object can only call member functions that have been declared as const, which are not allowed to modify the object instance it is being called on.

Exercises:
1) Consider the following functions and variable declarations.
   a) Draw a memory diagram for the variables declared in `main`. It might be helpful to distinguish variables that are constant in your memory diagram.

```
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.
c) If we have functions `void Foo(const int& arg);` and `void Bar(int& arg);`, what does the compiler think about the following lines of code:

```c
Bar(x_ref);
Bar(ro_x_ref);
Foo(x_ref);
```

d) How about this code?

```c
ro_ptr1 = (int*) 0xDEADBEEF;
x_ptr = &ro_x_ref;
ro_ptr2 = ro_ptr2 + 2;
*ro_ptr1 = *ro_ptr1 + 1;
```
2) Refer to the following poorly-written class declaration.

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:

<table>
<thead>
<tr>
<th>Code Snippets</th>
<th>Error?</th>
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<th>Error?</th>
</tr>
</thead>
<tbody>
<tr>
<td>const MultChoice m1(1,'A'); MultChoice m2(2,'B');</td>
<td></td>
<td>const MultChoice m1(1,'A'); MultChoice m2(2,'B');</td>
<td></td>
</tr>
<tr>
<td>cout &lt;&lt; m1.get_resp();</td>
<td></td>
<td>m1.Compare(m2);</td>
<td></td>
</tr>
<tr>
<td>cout &lt;&lt; m2.get_q();</td>
<td></td>
<td>m2.Compare(m1);</td>
<td></td>
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</table>

b) What would you change about the class declaration to make it better? Feel free to mark directly on the class declaration above.
3. Refer to the following file definitions.

<table>
<thead>
<tr>
<th></th>
<th>Point.h</th>
<th></th>
<th>Point.cc</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>class Point { ... };</td>
<td></td>
<td>#include &quot;Point.h&quot;</td>
<td></td>
</tr>
<tr>
<td>UsePoint.cc</td>
<td>#include &quot;Point.h&quot;</td>
<td>#include &quot;Thing.h&quot;</td>
<td>// defs of methods</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>int main( ... ) { ... }</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UseThing.cc</td>
<td>#include &quot;Thing.h&quot;</td>
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<tr>
<td></td>
<td></td>
<td>int main( ... ) { ... }</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Thing.h</th>
<th></th>
<th>Alone.cc</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>struct Thing { ... };</td>
<td></td>
<td>int main( ... ) { ... }</td>
<td></td>
</tr>
<tr>
<td></td>
<td>// full struct def here</td>
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</table>

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

b. Write the corresponding Makefile for Point
Bonus: Const Const Const
Which of the following lines will result in a compiler error?

<table>
<thead>
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<tr>
<td>int z = 5;</td>
<td></td>
</tr>
<tr>
<td>const int* x = &amp;z;</td>
<td></td>
</tr>
<tr>
<td>int y = &amp;z;</td>
<td></td>
</tr>
<tr>
<td>x = y;</td>
<td></td>
</tr>
<tr>
<td>*x = *y;</td>
<td></td>
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<td>int z = 5;</td>
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<tr>
<td>int* const w = &amp;z;</td>
<td></td>
</tr>
<tr>
<td>const int* const v = &amp;z;</td>
<td></td>
</tr>
<tr>
<td>*v = *w;</td>
<td></td>
</tr>
<tr>
<td>*w = *v;</td>
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Bonus: What does the following program print out?  
| Hint: box-and-arrow diagram! |

```c
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;
    cout << "  rx: " <<   rx << endl;
    cout << "  *px: " <<  *px << endl;
    cout << "  &x: " <<   &x << endl;
    cout << "  rpx: " <<  rpx << endl;
    cout << "  *rpx: " << *rpx << endl;

    return EXIT_SUCCESS;
}
```
Bonus: Mystery Functions
Consider the following C++ code, which has ___???___ in the place of 3 function names in main:

```cpp
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
PrintThing(foo);

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

cout << "(3) ";
???(foo); // mystery 3
PrintThing(foo);

return 0;
}
```

Program Output:
(0) Thing: 5, true
(1) Thing: 6, false
(2) Thing: 3, true
(3) Thing: 3, true

Possible Functions:
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.