Highlights

- pointers

```c
int x = 6;
int* xp;
xp = &x;
```
object vs memory address

An object is simply a box in memory and if you pass this into a function it makes a copy.

A memory address is where a box is located and if you pass this into a function, you can change the variable everywhere.

<table>
<thead>
<tr>
<th>Memory address</th>
<th>Object (box)</th>
</tr>
</thead>
<tbody>
<tr>
<td>arrays</td>
<td>int, double, char, ...</td>
</tr>
<tr>
<td>using &amp;</td>
<td>classes</td>
</tr>
</tbody>
</table>

(pointers)
Review: address vs value

Consider the following:

```cpp
int x=6;
std::cout << x << "\n";
std::cout << &x << std::endl;
```

x is a variable (a box containing value 6)

&x is a memory address (sign pointing to box)
- Rather than giving the value inside the box, this gives the whole box
(see: memAddress.cpp)
Review: address vs value

Similar to a URL and a webpage
-A URL is not a webpage, but a link to one

Webpage g;
cout << &g;
Pointers

Just as & goes from value (webpage) to address (url), * goes the opposite:

Webpage g;
URL u = &g;
Webpage g2 = *u;
Pointers

You can also think of pointers as “phone numbers” and what they point to as “people”
Pointers

If multiple people have the same “phone number”, they call the same person (object)

1-800-presdnt (pointer/memory address)

Trump (object)

1-800-presdnt
A pointer is used to store a memory address and denoted by a * (star!)

```cpp
int x = 6;
int* xp;
xp = &x;
```

Here variable xp is a integer pointer

```cpp
cout << *(&x); // *(&x) same as x
```

The * goes from address to variable (e.g. like hitting ENTER on a url, or “call” on a phone contact) (See: pointerBasics.cpp)
Pointers (phone analogy)

Make a phone-number for an person (int)

```c
int Jackeline_Wu = 9;
```

Make a person (int) “Jacqueline Wu” exist

```c
int* jacky;
jacky = & Jackeline_Wu;
```

(& = address of)

Save Jacqueline Wu's phone number into the “jacky” contact

```c
*jacky = 9001;
```

(= call up)

Call the “jacky” contact (and connect with Jacqueline Wu)
It is useful to think of pointers as types:

```c
int* xp;
```

Here I declared a variable “xp” of type “int*”

Just like arrays and [], the use of the * is different for the declaration than elsewhere:

Declaration: the * is part of the type (```int* xp;```

Everywhere else: * follows the pointer/address (i.e. ```*xp = 2;``` puts 2 where xp is pointing to)
Pointers and references allow you to change anything into a memory address that you want. This can make it easier to share variables across functions.

You can also return a pointer from a function (return links to variables) (see: returnPointer.cpp)
Pointers

Why do we need pointers? (memory addresses are stupid!!!)

Suppose we had the following class:

class Person{
    string name;
    Person mother;
    Person father;
};

Will this work?
As is, it will not... it is impossible to make a box enclose two other equal sized boxes.
The only way it can enclose something like itself is that thing is smaller.
Pointers

To do this we can use pointers instead!

A pointer does not store the whole class data, it only remembers where it is (like a URL)

```cpp
class person{
    string name;
    person* mother;
    person* father;
};
```

(See: person.cpp) (more on this shortly)
When dealing with classes, often you need to dereference (*) and access a member (.)

There is a shortcut to de-reference and call a member (follow arrow and go inside a box)

You can replace (*var).x with var->x, so...

\[
(*\text{me.mother}).\text{name};
\]

... same as ...

\[
\text{me.mother}->\text{name};
\]
Person class

How would you make your grandmother? How could you get your grandmother using only yourself as a named object?

```cpp
class person{
    string name;
    person* mother;
    person* father;
};
```

(See: personV2.cpp)