C++ Pointers.
A pointer is a data type that stores memory addresses.

Example:
```cpp
int x, y;
float z;
x = 7;
y = x + 3;
cout << y;
cout << \&y;
```

Example:
```cpp
int x;
int y;
x = \&y;
int *p;
p = \&y;
```

Example:
```cpp
int *p1;
string *s;
char *r;
```

Pointers carry type.

Example:
```cpp
int x;
char *p;
p = \&x;
float *q;
q = \&x;
```

The special Value **NULL**

```cpp
char *p = NULL;
char *q = NULL;
```

Example:
```cpp
int x;
const int y = 3;
int *p;
p = \&y;
```
```
Example:
int i = 7;
int *p;
p = &i;
cout << *p;
*p = 5;
cout << i;
int k = q;
p = &k;
const int j = 12;
p = &j;
```

Example:
```
int x;
int *p;
const int *q;  // pointer to integer constant: q=&j
int const *r = &x;  // constant pointer to integer
const int const *s = &x;
'''

pointers as parameters:
```
int foo (int* p);
```

pointers as return values:
```
char* foo (int x);
```

arrays of pointers:
```
int * z[10];
```
Data Structures Page 3

**Pointers in classes**

```cpp
class Chicken
{
    int age;
    int *whatever;
};
```

**Exercise:**
```cpp
int x, y;
int *p;
p = &y;
*p = 7;
y = 5 * *p;
int **q;
q = &p;
**q = 3;
*q = &x;
```

**Pointers to Arrays:**
```
Example:
int z[5];
int *p;
p = &z[0];
p = z;
p[3] = 42;
int *q;
q = &z[2];
q[1] = 5;
```

**Pointers to Classes / Structs**
```
Example:
class Pineapple
{
public:
    int x;
    float s;
};

Pineapple Jacob;
Pineapple *p = &Jacob;
*p.x = 7;
(*p).x = 7;
p->x = 7;
p->s = 3.9;
```

**The new and delete operators**
```
Example:
int *p;
p = new int;
*p = 5;
...
delete p;
p = NULL;
```
**Example:**

```cpp
int *p;
int x;
cin >> x;
p = new int[x];
p[3] = 12;
x = 678;
......
delete [] p;
p = NULL;
```

**Problems with Pointers**

- **Dangling Pointer** - using a pointer with an invalid address/value
- **Memory Leak** - when dynamic variables become unreachable

**Dangling Pointers**

**Example:**

```cpp
int *p;
*p = 5;
```

**Segmentation Fault**

**Example:**

```cpp
int *p = NULL;
*p = 5;
```

**Memory Leak**

```cpp
int *p = new int[3];
delete [] p;
p[2] = 5;
```

**Example:**

```cpp
int *p = new int[5];
p = new int[5];
```

**Example:**

```cpp
int *p;
while ( !done ) {
    p = new int[5];
}
```

**Pointers and 2D Arrays**

**Example:**

```cpp
int **p;
p = new int*[5];
```
Example:
int **p;
p = new int*[5];
for( int i=0; i<5; i++ )
    p[i] = new int[3];
p[3][1] = 5;

for( int i=0; i<5; i++ )
    delete [] p[i];
delete [] p;
p = NULL;