Tutorial 8

- Arrays.
- Pointer arithmetic.
- Efficiency.

Arrays

Arrays can be thought of as pointers to a block of memory. They can be used to store a **fixed number** of elements of the **same type**.

Example of array syntax:

```c
int my_array[3] = { 1, 2, 3 };  
int x = my_array[0];  // x = 1
```

In the above code, `my_array` is a pointer to the first element of the array. The `[i]` syntax **dereferences** the `(i + 1)th` element of the array.

The syntax `a[i]` is shorthand for the equivalent expression `*(a+i)`.

Array Initialization

There are several ways to define an array:

```c
int a[3];  // array is not fully defined

int b[3] = { 1, 2, 3 };  // array length is explicit

int c[] = { 1, 2, 3 };  // array length is inferred  
// c has length 3, and we cannot change it later

int d[3] = {0};  // array of length 3, filled with zeros

int e[8] = { 7, 4, 1 };  
// {7, 4, 1, 0, 0, 0, 0, 0}
```
Array Exercise

// reverse(arr, len) reverses arr, an array of len integers.
// requires: arr != NULL, len > 0,
// arr is an array of length len
// effects: mutates arr
void reverse(int arr[], int len);

Array Exercise 2, Electric Boogaloo

Let's retry Midterm Question 4f) but with arrays!

// no_dups(n) prints all numbers from 1 to n that
// contain no duplicate digits.
// requires: n >= 1,
// effects: prints output
void no_dups(int n);

Pointer Arithmetic

Certain arithmetic operations can be performed on pointers. An
integer can be added or subtracted to a pointer, and pointers of the
same type can be subtracted from one another.

int a[10];
int *p = a; // a is a pointer to first element
int *q = &a[9]; // address of 10th element
q = a + 9; // equivalent
a[2] = q - p; // set the value of 3rd element as 9
q = p + 1; // now q == &a[1]

Addition of pointers is not allowed.
Array Notation vs Pointer Notation

If you ask the right people, you can start heated debates on whether
to use `int a[]` or `int *a` in a parameter declaration.

*They are equivalent.*

Some people will argue for the first style because it is clear that the
function takes an array.

Others believe the first style is misleading, as the array isn’t actually
passed by value and using `sizeof` on it is unintuitive.

**You should be familiar with both ways of passing arrays.**

Pointer Arithmetic: Example

Implement the following function using only pointer notation.

```c
// ptr_product(arr, len) returns the product of len
//   integers in array arr (using pointer arithmetic).
// requires: arr != NULL, len > 0,
//   arr is an array of length len
int ptr_product(const int *arr, int len);
```

Now implement the function again using array notation instead.

```c
int arr_product(const int arr[], int len);
```

Efficiency

- When looking at a function, it is often useful to understand its
  running time.
- To do this, we compute the running time as a function of the
  input size, and use Big O notation to simplify the computation.
Efficiency and Arrays

- Accessing a single variable (or item in an array) has constant runtime, $O(1)$.
- Iterating fully over an array of length $n$ has linear runtime, $O(n)$.