## C philosophy: small is beautiful

- Is underlying philosophy of Unix too
- Each program does just one thing
  - *Pipe* together to do more complicated things
  - Applies at level of C functions too
- Less typing is better than more typing
  - Is why Unix commands are so short – ls, cp, mv, …
  - C programs are usually written tersely too
- Users/programmers know what they are doing
  - So brevity works, and few restrictions apply

## C data types and variables

- A variable name refers to a memory location
  - Compiler must know the data type stored there
- Just a few basic types (most sizes vary)
  - `char` – 1 byte (8 bits) – number represents a character
  - `int` – for integers
  - `float` and `double` – for floating point numbers
- Also some qualifiers – modify the basic types
  - `short`, `long` – apply to int (and `long double` too)
  - `unsigned` – apply to `int` and `char` – positive values
- Must declare variable before using it
  - e.g., `int x;` – now can store an integer: `x = 17;`

## C constants

- Integers, floats, characters, and C strings:
  - `15`, `017`, `0xf` – same value in dec, oct, hex
  - `0.0012`, `1.2e-3` – regular and scientific floats
  - `'c'`, `'\n'` – individual chars; also `"string"`
- Symbolic constants – e.g., `#define MAX 50`
  - Text *substitution* by C preprocessor – more later
  - New way borrowed from C++: `int const MAX = 50;`
- Enumerations – e.g., `enum state { in, out };`
  - Type is `enum state` – `in`, `out` are particular *values*

## C function basics

- Must be declared before use
  - Can do with forward declaration (prototype):
    - e.g., `long multiply (int, int);`
    - Parameter names are optional in prototypes
- Must be defined somewhere (for linker)
  - Definition includes header and function body
  - Parameter names are required
    - Parameters are always *copies* of argument values
  - `return` – required if type is not void
    - Value returned is also a copy

## Arrays and character strings

- Declare array and fixed size at same time
  - `int x[50];` /* size must be a constant */
  - May not reassign array name: `x = …` /* illegal */
- C string: a `char` array, terminated by `'\0'`
  - e.g.,
```
int length(char s[]) {/* string length */
        int i;
        for (i = 0; s[i] != '\0'; i++);
        return i;
    } /* note: size of array is probably greater */
```
- See character and string processing demo programs in `~mikec/cs12/demo01/`
  - Also shows simple input/output and C program form

## Formatted printing to stdout

- `printf(format, value, value, …);`
  - format – a string with descriptors for each value
- To print a string variable – use `%s` descriptor:
  `printf("my string is %s", stringvar);`
- To print a constant string – no descriptors/values
  - Or use `puts("…")` – prints `'\n'` at end of string too
- To print an integer (decimal) and a float – `%d`, `%f`:
  - `printf("int is %d, float is %f", ivar, fvar);`
  - Or describe the field width and/or precision to print:
    `printf("int is %5d, float is %8.2f", ivar, fvar);`
- More `printf` in KR chapter 7 – and see appendix B

## C Pointers

- What are C pointers?
  - Ans: *variables* that store memory *addresses*
    - i.e., they "point" to memory locations
    - And they can vary – be assigned a new value
- Background: every variable really has two values

```
int m = 37;  /* What does the compiler do? */
```

  - (1) sets aside 4 bytes of memory (usually) to hold an `int`
  - (2) adds `m` and this memory address to a symbol table
  - (3) stores 37 (one value) in those 4 bytes of memory
  - The other value – a.k.a. lvalue – is the memory address

## * and &

- The * has 2 meanings for C pointers
  - (1) to declare a pointer variable:

```
int *p; /* now p can point to an int */
```

  - (2) to dereference a pointer:

```
*p = 19; /* stores 19 at location p points to */
printf("an int value: %d", *p);
     /* finds and prints the value where p is pointing */
```

- The & retrieves a variable's lvalue:

```
p = &m; /* points p at address where m is stored */
scanf("%d", &m); /* gets an input value for m */
scanf("%d", p); /* same as above in this case */
```

## Pointer types

- Compiler knows type of data a pointer points to
  - For dereferencing, and for pointer arithmetic
- e.g., an `int *` can *only* point to an `int`
- Exception: a `void *` can point to any type
  - e.g.,

```
double d = 1.5;
int x = 6, *ip;
void *vp = &d; /* vp points to a double */
vp = &x;   /* okay, now vp points to an int */
```

  - But cannot dereference `vp` directly – must cast first:

```
printf("%d", *vp); /* error */
ip = (int *)vp; /* now can dereference ip */
```

## Array names are not pointers
(but they are close)

- `int x[10];` /* What does this do? */
  - Allocates 10 *consecutive* `int` locations
  - *Permanently* associates `x` with the address of the first of these `int` locations – i.e., `x` always points to `x[0]`
- So `&x[i]` is exactly the same as `(x+i)`
  - And `x[i]` is exactly the same as `*(x+i)`
- Also, if `p` is a pointer to `int`, then:
  - `p = &x[0]` is exactly the same as `p = x`
    - But `x = p` is illegal, because `x` is not really a pointer
  - Then `p[i]` is an alias for `x[i]`
  - `++p` moves `p` to point at `x[1]`, and so on