Slide 1

Administrivia

- Reminder: Homework 5 due today.

Slide 2

Dynamic Memory and C

- With the C89 standard, you had to decide when you compiled the program how big to make things, particularly arrays — a significant limitation.
- Variable-length arrays in C99 standard help with that, but don't solve all related problems:

  In many implementations, space is obtained for them on "the stack", an area of memory that's limited in size.

  You can return a pointer from a function, *but* not to one of the function's local variables (because these local variables cease to exist when you return from the function).

Slide 3

Dynamic Memory and C, Continued

- "Dynamic allocation" of memory gets around these limitations — allows us to request memory of whatever size we want (well, up to limitations on total memory the program can use) and have it stick around until we give it back to the system.

  (The trick here is that most implementations differentiate between two areas of memory, a "stack" used for local variables, and a "heap" used for dynamic memory allocation. Usually the former is more limited in size.)

- To request memory, use `malloc`. To return it to the system, use `free`. (For short simple programs you can not bother with `free`, but for longer and more complicated programs, you should clean up when you can, or eventually you may run out of memory.)

- Compare/contrast with Java — allocate space for objects with `new`, no explicit deallocation, garbage collection.

Slide 4

Dynamic Memory and C, Continued

- Examples:

```
int * nums = malloc(sizeof(int) * 100);
char * some_text = malloc(sizeof(char) *
20);
free(nums);
```

- Some books/resources recommend "casting" value returned by `malloc`. Other references recommend the opposite! But you should check the value — if `NULL`, system was not able to get that much memory.

Slide 5

Function Pointers

- You know from Java that there are situations in which it's useful to have method parameters that are essentially code (e.g., GUI listener methods, `compareTo` method for sorting, `run` method for threads).
- In Java, you often do this by way of a class whose main or only purpose is to hold the needed code.
- In C, however, you can explicitly pass a pointer to the function.

Slide 6

Function Pointers in C

- The type of a function pointer includes information about the number and types of parameters, plus the return type.
- Example — last parameter to library function `qsort` (in its `man` page). Call this by providing, in your code, a function with declaration

```
int my_compare(const char *, const char *);
```

and using `my_compare` as the last parameter to `qsort`.

Slide 7

Example — Revised Sort Program

- Change the program to allow specifying at runtime that N inputs are to be generated.
- Also change to use `qsort`.

Slide 8

User-Defined Types

- So far we've only talked about representing very simple types — numbers, characters, text strings, arrays, and pointers. You might ask whether there are ways to represent more complex objects, such as one can do with classes in Java.
- The answer is "yes, sort of" — C doesn't provide nearly as much syntactic help with object-oriented programming, but you can get something of the same effect. But first, some simpler user-defined types . . .

Slide 9

User-Defined Types in C — `typedef`

- `typedef` just provides a way to give a new name to an existing type, e.g.:

```
typedef charptr char *;
```

- This can make your code more readable, or allow you to isolate things that might be different on different platforms (e.g., whether to use `float` or `double` in some application) in a single place.

Slide 10

User-Defined Types in C — `enum`

- In C (and in some other programming languages) an *enumeration* or an *enumerated type* is just a way of specifying a small range of values, e.g.

```
enum basic_color { red, green, blue, yellow };
enum basic_color color = red;
```

  This can make code more readable, and sometimes combines nicely with `switch` constructs.

- Under the hood, C enumerated types are really just integers, though, and they can be ugly to work with in some ways (e.g., no nice way to do I/O with them).

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User-Defined Types in C — `struct`

- More complex (interesting?) types can be defined with `struct`, which lets you define a new type as a collection of other types — something like a Java class, but with no methods, and public fields only.
- Two versions of syntax (next slide) . . .

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User-Defined Types in C — `struct`

- One way to define uses `typedef`:

```
typedef struct {
    int numerator;
    int denominator;
} fraction;
fraction f1;
```

- Another way doesn't:

```
struct fraction {
    int numerator;
    int denominator;
};
struct fraction f1;
```

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User-Defined Types in C — `struct`, Continued

- Either way you define a `struct`, how you access its fields is the same:

  `.` if what you have is a `struct` itself:

```
struct fraction f1;
f1.numerator = 100;
f1.denominator = 100;
```

  `->` if what you have is a pointer to a `struct`:

```
struct fraction * f1_ptr = &f1;
f1_ptr->numerator = 100;
f1_ptr->denominator = 100;
```