Lecture 6: Character Operations and Arrays

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[With material/slides from Guohui Lin, Davood Rafei, and Michael Buro. Most examples taken from K.N. King's book]

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Agenda

- char type
- Character operations & character-handling functions
- One-dimensional arrays
- Multi-length arrays
- Variable-length arrays
- Quick intro to string functions

Readings

- Textbook Chapter 7.3
- Chapter 8

Characters & their Operations

Character Types

```
char ch;
int i;
ch = 'A'; //variable ch is assigned the value of A
i = ch; //variable i has the value 65 (ascii value of A)
```

- You will be dealing with character types in Assignment 1
- Characters are treated as integers, which means that all operations on integers can be done with characters
- Values of type char are machine dependent, because there are different character set. ASCII is the most popular character set. See http://www.asciitable.com/
- Use the conversion specifier `%c`

Character-handling Functions

- Convert case using `toupper` (need to `#include <ctype.h>`):

```
ch = toupper(ch);
```

- `toupper(char)` simply implements:

```
if (ch >= 'a' && ch <= 'z')
    ch = ch - 'a' + 'A';
```

Reading and Writing Characters

- Take care of white space (`scanf("%c", &ch);` vs. `scanf(" %c", &ch);`)
- Read a single character from the keyboard using `ch = getchar();`
- Write a single character to the screen by `putchar(ch);`

demo: read_char.c

Idioms to Skip the Rest of the Line

```
do {
    scanf("%c", &ch);
} while (ch != '\n');
```

```
while ((ch = getchar()) != '\n') ;
```

```
do {
   ch = getchar();
} while (ch != '\n');
```

```
while (getchar() != '\n') ;
```

Arrays

Variables

- *Scalar* variables hold a single data item (e.g., int x; float y; char c)
- `Aggregate` variables store a collection of values
- C has two kinds of aggregates:
  - arrays
  - structures

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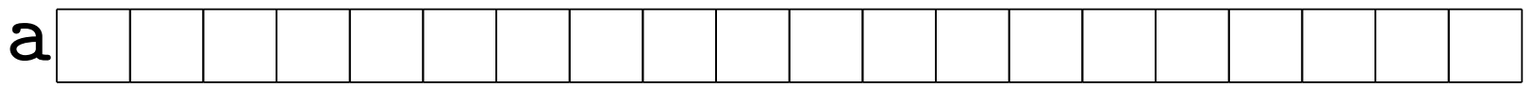
One-dimensional Arrays

- Data structure that contains a number of data values **of the same type**
- Each value in the array is called an *element*
- Each element can be accessed by its position within the array
- Declaring an array of type int with 20 elements: `int a[20];`



One-dimensional Arrays

Cont'd

- The number of elements in an array is called its *length*
- Length must be a **constant** integer (e.g., `10, 1+4`) or a macro that gets preprocessed to an integer (e.g., `LENGTH` where we have `#define LENGTH 10`)
- Conceptually, elements of an array are arranged consecutively in memory
- Index/subscript starts at 0
- `a[2]` is:
  - an lvalue (i.e., object stored in computer memory)
  - the 3rd element of array `a`
  - has type `int` and can be treated as an `int` value

Array Examples

```
#define N 20;
int main (void){
  int a[N], i;
  for (i = 0; i < N; i++)
    a[i] = 0;

  for (i = 0; i < N; i++)
    scanf("%d", &a[i]);

  int sum = 0;

  for (i = 0; i < N; i++)
    sum += a[i];
  return 0;
}
```

```
#define N 20;
int main (void){
  int a[N], i;
  for (i = 1; i <= 2 * N; i++) {
    a[i] = 0;
    printf("a[%d] = %d\n", i,
                a[i]);
  }

  return 0;
}
```

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```

Is there anything wrong with these examples?

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   int a[N], i;
   for (i = 0; i < N; i++)
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      printf("a[%d] = %d\n", i,
                  a[i]);
   }

   return 0;
}
```

goes beyond the array bounds!

Is there anything wrong with these examples?

Array Initialization

Can initialize array when it is declared:

```
int b[10] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
int c[10] = {1, 2, 3, 4, 5, 6, 7 + 8};
int d[10] = {0};
int e[] = {1, 2, 3, 4, 5, 6, 7};
int f[10];
```

Can use designated initializers (only c99):

```
  int f[10] = {[2] = 2, [7] = 9, [9] = 7, [2] = 3};
```

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```

designators

Same rules as above apply for unspecified indices

Group Exercise

(variation of p166)

Write a program that counts the number of repeated digits in a given number as follows:

```
Enter a number: 3456787
7 is repeated 2 times

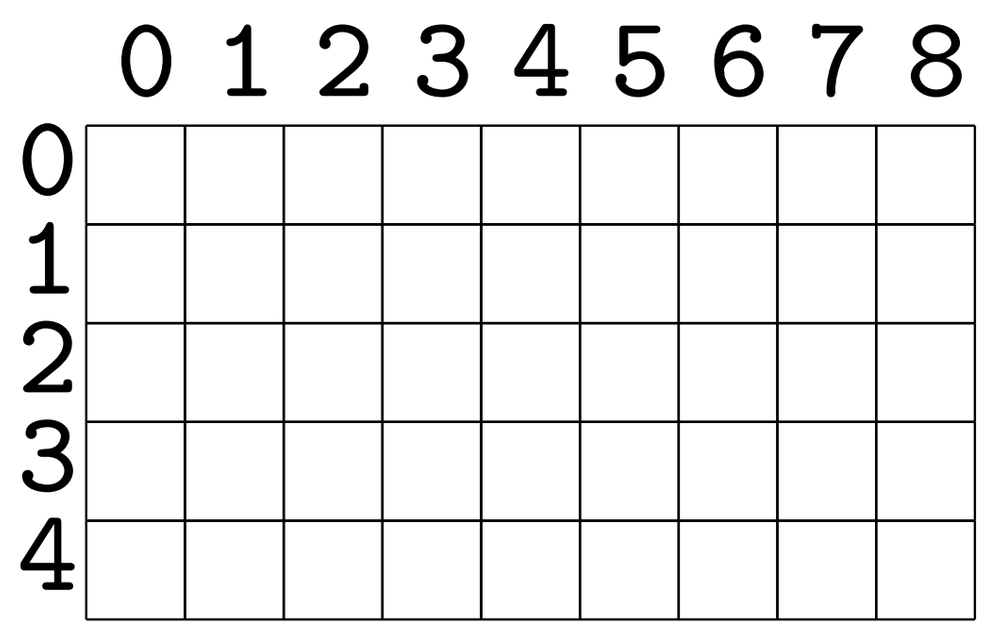
Enter a number: 97585788
5 is repeated 2 times
7 is repeated 2 times
8 is repeated 3 times

Enter a number: 9758
No repeated digit
```

Group Exercise!

Multi-dimensional Arrays

- An example would be a 2-d array (a.k.a a matrix in mathematical terminology): `int a[5][9];`
  - 5 rows, indexed from 0
  - 9 columns, indexed from 0
  - each element in the array has the same type. In this case, `int`.



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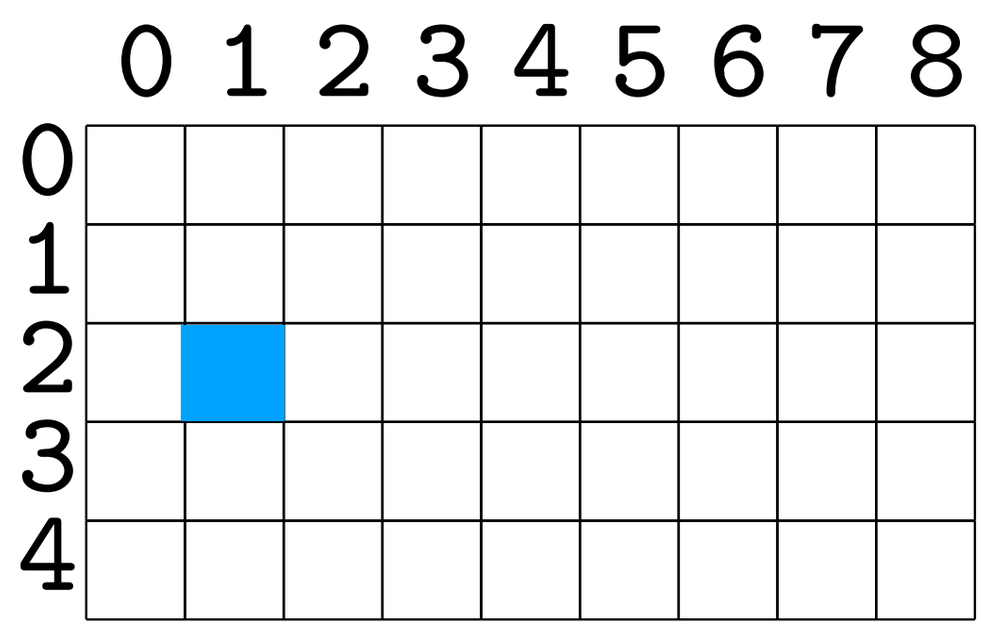
```
a[2][1];
```



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  - 5 rows, indexed from 0
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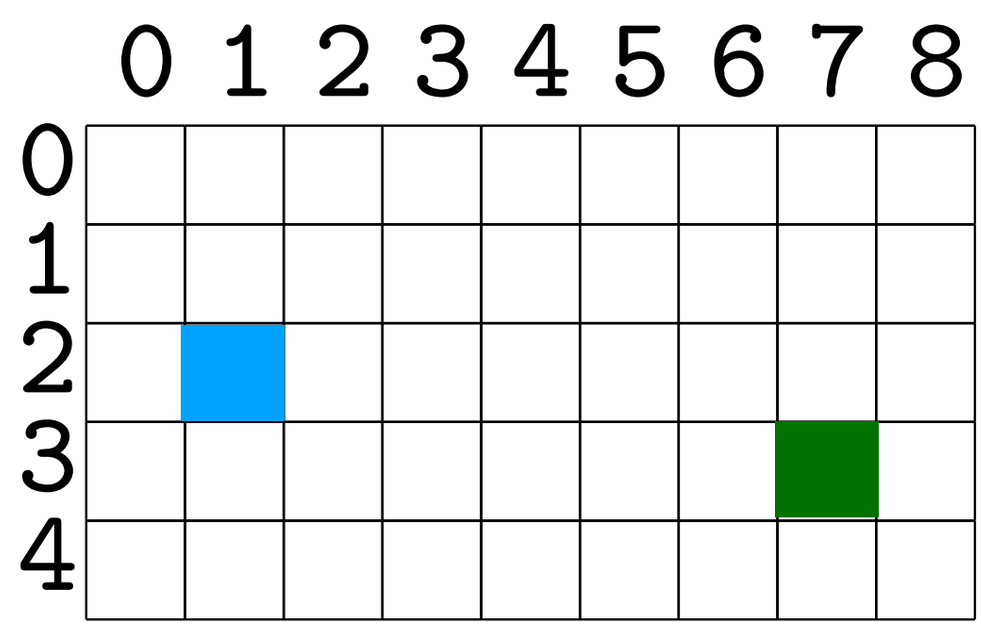
```
a[2][1];

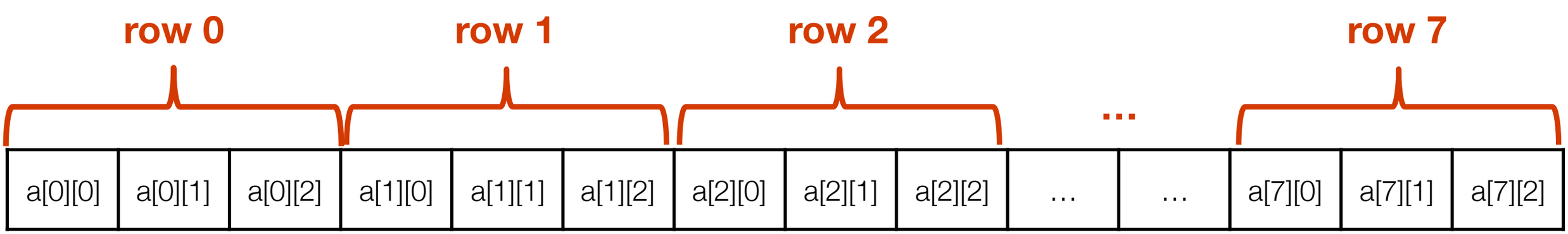
a[3][7];
```



Memory Representation of Multi-dimensional Arrays

- Although we visualize 2-d arrays as a table/matrix, this is not how they are represented in memory. Multi-dimensional arrays in C are stored in row-major order.

```
int a[8][3];
```



Initializing a 2-D Array

- Use several 1-D initializers, one per row, or designated initializers in C99. Unspecified values will be initialized to 0.

```
int a[5][9] = {{1, 5, 1, 7, 9, 0, 1, 1, 1},
               {0, 3, 1},
               {1, 1, 0, 1, 1, 1},
               [3][2] = 10,
               [4][8] = 20};
```

- Constant arrays can be declared with the keyword `const`. This means that the program cannot change the value of any element. Useful when you want a “dictionary” to look up things.

```
const char card_suits[] = {'D', 'H', 'C', 'S'};
```

Accessing Each Element in an Array

- Nested loops are ideal for this task
- For 2-d arrays, you want one outer loop that steps through every row index and an inner loop that steps through every column index

Randomly Dealing a Hand of Cards

```
Enter a number of cards in hand: 5
Your hand: 7C 2S 5D aS jH
```

Things to think of:

- how to pick cards randomly?
- how to avoid repeated cards?

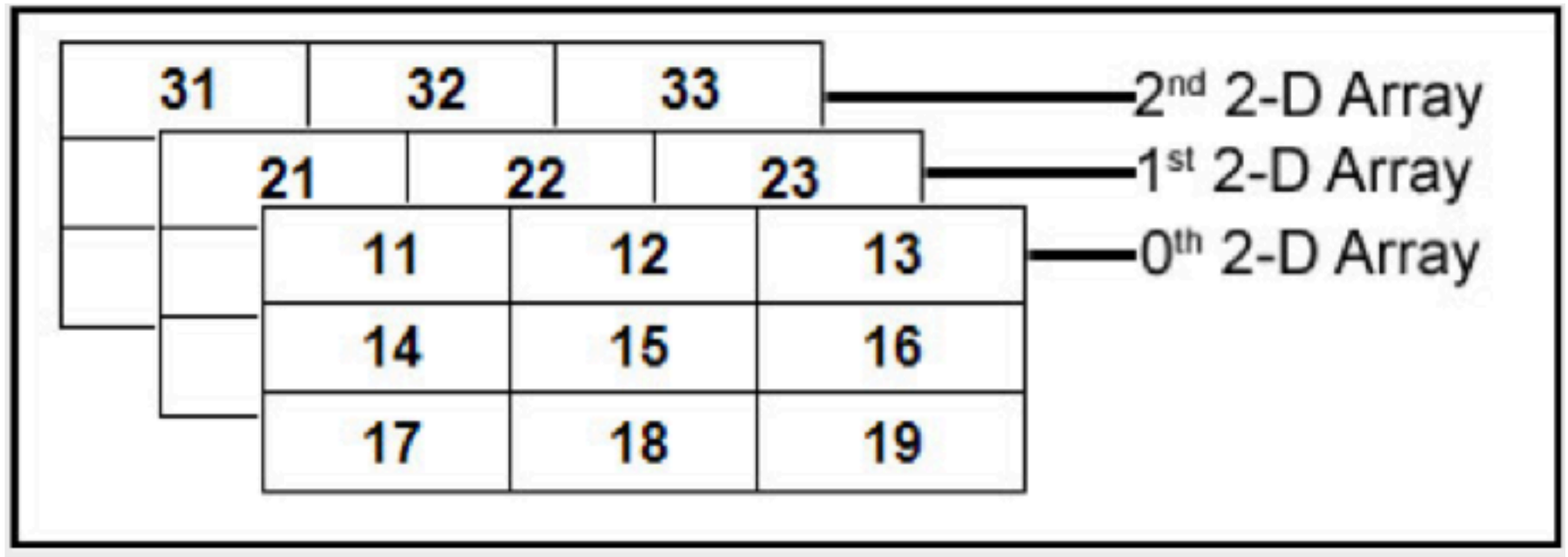
Group Exercise!

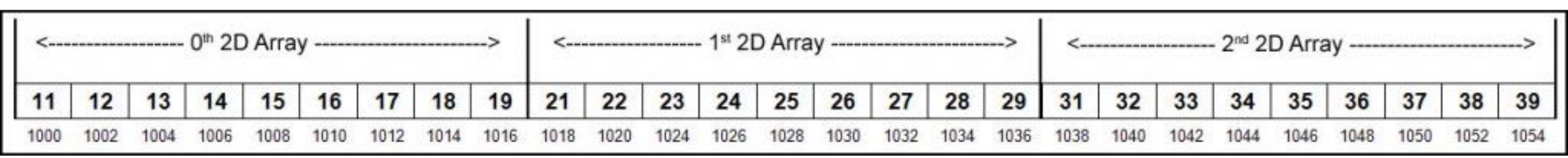
Higher-dimensional Arrays

- A 2D array is an array of arrays. A 3D array is an array of arrays of arrays, and so on.
- The same concepts of initialization and memory layout apply to higher-dimensional arrays.

Example of 3-D Array

```
int arr[3][3][3]=
{
  {
    {11, 12, 13},
    {14, 15, 16},
    {17, 18, 19}
   },
   {
    {21, 22, 23},
    {24, 25, 26},
    {27, 28, 29}
   },
   {
     {31, 32, 33},
     {34, 35, 36},
     {37, 38, 39}
    },
};
```





[Source: https://owlcation.com/stem/How-to-work-with-Multidimensional-Array-in-C-Programming]

Variable-length Array (only with `-std=c99`)

- Allows the use of an expression rather than a constant to specify the length of the array

```
#include <stdio.h>

int main(void) {
    int i, n;

    printf("Enter the length of array: ");
    scanf("%d", &n);

    int a[n]; /* declare a length-n array a */

    for (i = 0; i < n; i++) {
        if (a[i] == 0)
            printf("a[%d] has a default value %d\n", i, a[i]);
        else
            printf("a[%d] has a system leftover value %d\n", i, a[i]);
    }

    return 0;
}
```

Multi-dimensional Variable Length Arrays

```
#include <stdio.h>

int main(){

    int rows, columns;

    printf("Enter num of rows: ");
    scanf("%d", &rows);

    printf("Enter num of columns: ");
    scanf("%d", &columns);

    int ages[rows][columns];

    for (int i = 0; i < rows; i++)
        for(int j = 0; j < columns; j++)
            ages[i][j] = i + j;

    for (int i = 0; i < rows; i++) {
        for(int j = 0; j < columns; j++)
            printf("%d\t", ages[i][j]);

        printf("\n");
    }

    return 0;
}
```

String Functions

(Covered in much more detail later)

Strings in C

- Strings in C are basically character arrays, with a null character `'\0'` after the last letter of the string.
- Example:

```
char name[10];
printf("What is your name?");
scanf("%s", name);
```

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← **note that there is no & before the array name**

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printf("What is your name?");
scanf("%s", name);
```

← **note that there is no & before the array name**

name

a	l	i	c	e	\0				

Some Notes about Strings

- Remember that `scanf` ignores whitespace and the newline character is a whitespace so `scanf` will just ignore the newline entered after the string
- This means that `scanf` can read only one word at a time
- Reading a string with `scanf` will add the null character for you at the end of the word it reads
- If you want to read a whole line that might have multiple words, use the `fgets` function: `fgets(name, 9, stdin);` In general, reading input lines with fgets is preferred as we will see later.
- If you want to compare two strings (i.e., null-terminated character arrays), use the `strcmp` function from the string.h library: `if (strcmp(argv[1], "-m") == 0) { … }`