10. File Input / Output
ENEE 140

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Today's Lecture

- Where we've been
  - Scalar data types
  - Arrays and strings
  - Functions
  - Random number generation
  - Control flow
  - Structuring complex programs
- Where we're going today
  - File Input/Output
- Where we're going next
  - Sorting

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Text File I/O

- Declaring and manipulating file variables

```
#include <stdio.h>
FILE *file;                                  declare the file variable
```

mode

  - Opening

```
file = fopen("filename.txt", "r");           open file for reading
```

    - Mode "r": open existing file for reading
    - Mode "w": open file for writing and erase existing content
    - Mode "a": open file for writing and append after existing content
    - Opening a file in modes "a" or "w" will create the file if it doesn't already exist
    - The `fopen()` function returns NULL if there is an error

  - Closing

```
fclose(file);                                close file
```

- **Frequent mistake: Not closing all the files you have opened**

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Text File I/O – continued

- Declaring and manipulating file variables

```
#include <stdio.h>
FILE *file;                      declare the file variable
int i;
char line[256];
```

  - Reading

```
fscanf(file, "%d", &i);          like scanf()
i = getc(file);                  like getchar()
fgets(line, 256, file);          read an entire line
```

  - Writing

```
fprintf(file, "%d", i);          like printf()
putc(i, file);                   like putchar()
fputs(line, file);               write an entire line
```

- The file must be open in order to read or write

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Review: Reading a File Line-by-Line

```
#include <stdio.h>

char line[MAX_LINE];
int a, b;
FILE *file;                                  variable representing the file

file = fopen("myfile.txt", "r");             open file for reading

if (file == NULL) {                          fopen() failed
 printf ("Could not open the myfile.txt file.\n");
    exit (-1);
}

...
fgets(line, MAX_LINE, file);                 read a line of text from the file
sscanf(line, "%d %d", &a, &b);               parse line with sscanf()
...

fclose(file);                                close file
```

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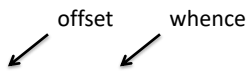
Position in the File

- When operating on a file, you read/write data sequentially
- You can change the current position in the file

```
rewind(file);                                go back to the beginning
```




```
fseek(file, 0, SEEK_END);                    go to the end of the file
```

  - `whence==SEEK_SET`: move `offset` bytes after the beginning of the file
  - `whence==SEEK_CUR`: move `offset` bytes after the current position
  - `whence==SEEK_END`: move `offset` bytes after the end of the file (`offset` may be negative)

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Special Files

- stdin, stdout, stderr

```
fscanf(stdin, “%d”, &i);        read from standard input
fprintf(stdout, “%d”, i);       write to standard output
fprintf(stderr, “%d”, i);       write to standard error stream
```

- You don’t have to open or close these special files
- By default, they are associated with the console
  - You can redirect them from the command line

```
prog <infile.txt            stdin redirected to infile.txt
prog >outfile.txt           stdout redirected to outfile.txt
prog 2>errfile.txt          stderr redirected to errfile.txt
prog1 | prog2               pipe stdout of prog1 into stdin of prog2
```

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printf/scanf Operate on the Standard Output/Input

```
printf("Hello %s\n", "world");
```

is equivalent to

```
fprintf(stdout,"Hello %s\n", "world");
```

```
scanf("%d\n", &a);
```

is equivalent to

```
fscanf(stdin, "%d\n", &a);
```

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Review: Formatted Input

- You can read from stdin, from a file or from a string

```
FILE *file;
int  read;
char string[256];
read = scanf(format, vars);              read from standard input
read = fscanf(file, format, vars);       read from file
read = sscanf(string, format, vars);     read from string
```

- These functions allow you to read scalar data types (format specifiers (`%d, %u, %f`, etc.) and strings (format specifier `%s`)
  - Remember to put an & before each scalar variable you are reading, e.g. `scanf("%d", &a);`
- The `Xscanf()` functions return the number of variables read
  - Return is 0: the input did not match the format provided
  - Return is EOF: the end-of-file was reached

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Review: Formatted Output

- You can write to stdout, to a file, or to a string

```
FILE *file;
int  read;
char s[MAX_S];
printf(format, vars);                    print to standard output
fprintf(file, format, vars);             print to file
sprintf(s, format, vars);                print to string
```

- `format` uses the same specifiers as the `Xscanf` functions
  - Additionally, may specify the width and precision, e.g. `"%4.2f"`
  - Width or precision may be specified as `*`: read it from next argument
    `printf("%.*s", MAX_S, s);` print at most `MAX_S` chars from `s`
    - For `Xscanf`, there is no modifier like `*` for `Xprintf`
  - For all specifiers and modifiers, see Chapter 7.2 or type `man printf`
- **With sprintf, you must be careful not to exceed the size of the string!**

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Pushing Back Characters

- We've seen: character I/O

```
c = getc(file);
putc(c, file);
```

read a character from file

write a character to file

- Can also push a character back to the input stream

```
ungetc(c, file);
```

c will be returned by the next read operation

- The formatted I/O functions (fscanf, fprintf) are implemented using the character I/O functions
  - Ability to push back characters is needed when reading formatted numbers
  - You know that you have all the digits of the number when you read a non-digit character
  - But that character may be part of the next formatted input requested (you've read one character too far) => push it back to the stream

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Status of File Streams

- File operations interact with hardware devices
  - These operations may fail
  - You must be able to distinguish between these errors and reaching EOF during normal file operations

- You can check the status of your `FILE*` stream

```
FILE *file;
if (ferror(file)) {…}
if (feof(file)) {…}
rewind(file);
```

check if an error occurred

check if you reached EOF

rewind clears the EOF and error flags

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Error Checking

- If you receive an error, you can print an error-specific message

```
#include <stdio.h>
FILE *file;
if ( (file=fopen(“my_file.txt”,"r")) == NULL) {
  perror(“Cannot open file”);
  exit(-1);
}
```

prints a message describing the error

- `perror()` appends an error-specific message to the text provided and prints it to stderr
  - You may also print additional error messages to stderr with `fprintf(stderr, …)`
- **Good programming practice: check the return values of all the functions you invoke – an error may have occurred!**

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Error Checking: Examples

```
#include <stdio.h>

FILE *file;
unsigned options;

if ( (file=fopen(“my_file.txt”,"r")) == NULL) {
  perror(“Cannot open file for reading”);
  exit(-1);
}
```

cannot proceed: file is not opened

```
if ( fscanf(file, "%u", &options) < 1 ) {
  fprintf(stderr, “File must start with an unsigned int”);
}

printf(“Read %u from the file\n”, options);

if ( ferror(stdout) ) {
  perror (“Error writing to stdout”);
}
```

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Review of Lecture

- What did we learn?

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Next Steps

- Next lecture
  - Low-level file I/O
- Assignments for this week
  - Try to understand how the shellsort implementation from **K&R Chapter 3.5** works; read **Chapter 5.11** for how to use the library function qsort()
  - No quiz
  - Weekly challenge: **selection_sort.c**
  - Homework: **`lab11.pdf`** (on http://ter.ps/enee140), due on Friday at 11:59 pm

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