C –
files (basic I/O)

Files…

What is a file?

- Logical collection of 1's and 0's

Two basic types

- Text (aka ASCII) files: plain printable text
  - Generally human readable and editable
  - Example:.c, .java, .txt, .tex, .sh, .html, .rst, .py
- Binary files: everything else
  - Kind of a misnomer (is ASCII not binary?)
  - Generally not human readable and editable (looks like garbage)
  - Usually generated and interpreted by some program
  - Examples: .o, .exe, .jpg, .mp3, .wmv, .doc, .xls, .ppt
- Somewhere inbetween…
  - Example: .ps, .pdf

The contents of a file:

ex1_ascii_file.txt

```
01000011010010010101010000100000
00110101001110010011001100100000
01001001010100110010000001001101
01011001001000000100110001001001
01000110010001010010000 1
```

Appears to be a random bunch of zeros and ones

The contents of a file:

ex1_ascii_file.txt

```
01000011010010010101010000100000
00110101001110010011001100100000
01001001010100110010000001001101
01011001001000000100110001001001
01000110010001010010000 1
```

Unless we assign it meaning!

Let’s break it down byte-by-byte…

The contents of a file:

ex1_ascii_file.txt

```
0100 0011  0100 1001  0101 0100  0010 0000
0011 0101  0011 1001  0011 0011  0010 0000
0100 1001  0101 0011  0010 0000  0100 1101
0101 1001  0010 0000  0100 1100  0100 1001
0100 0110  0100 0101  0010 0001
```

But we are programmers, we love hex!

The contents of a file:

ex1_ascii_file.txt

```
4 3  4 9  5 4  2 0
3 5  3 9  3 3  2 0
4 9  5 3  2 0  4 D
5 9  2 0  4 C  4 9
4 6  4 5  2 1
```

How many bytes is this file?

19 bytes!

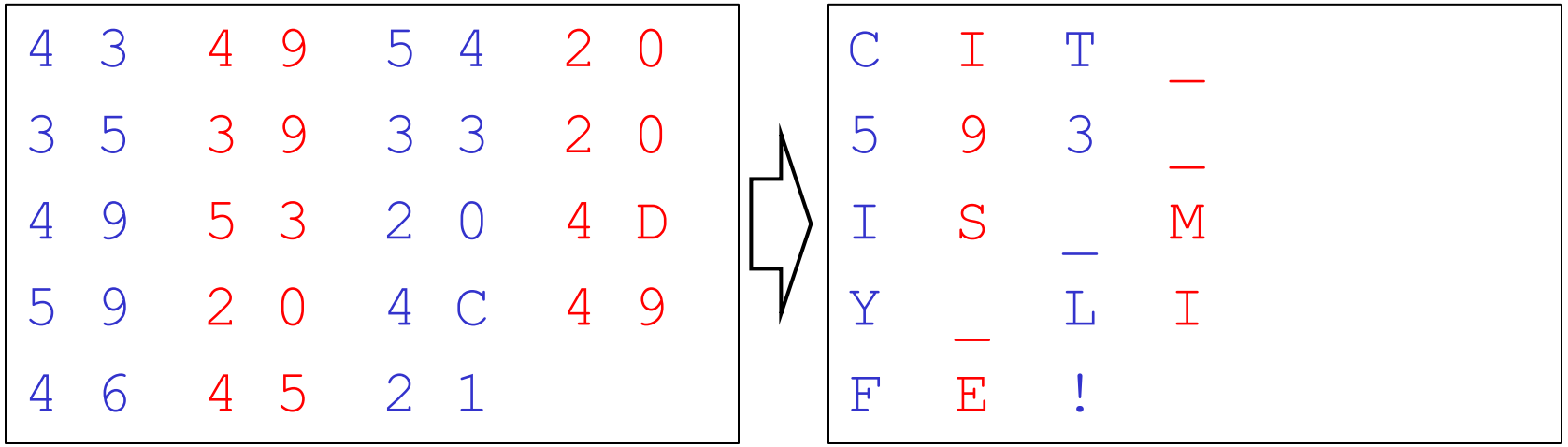
How do we assign meaning?

00	nul	10	dle	20	sp	30	0	40	@	50	P	60	`	70	p
01	soh	11	dc1	21	!	31	1	41	A	51	Q	61	a	71	q
02	stx	12	dc2	22	"	32	2	42	B	52	R	62	b	72	r
03	etx	13	dc3	23	#	33	3	43	C	53	S	63	c	73	s
04	eot	14	dc4	24	$	34	4	44	D	54	T	64	d	74	t
05	enq	15	nak	25	%	35	5	45	E	55	U	65	e	75	u
06	ack	16	syn	26	&	36	6	46	F	56	V	66	f	76	v
07	bel	17	etb	27	'	37	7	47	G	57	W	67	g	77	w
08	bs	18	can	28	(	38	8	48	H	58	X	68	h	78	x
09	ht	19	em	29	)	39	9	49	I	59	Y	69	i	79	y
0a	nl	1a	sub	2a	*	3a	:	4a	J	5a	Z	6a	j	7a	z
0b	vt	1b	esc	2b	+	3b	;	4b	K	5b	[	6b	k	7b	{
0c	np	1c	fs	2c	,	3c	<	4c	L	5c	\	6c	l	7c	|
0d	cr	1d	gs	2d	-	3d	=	4d	M	5d	]	6d	m	7d	}
0e	so	1e	rs	2e	.	3e	>	4e	N	5e	^	6e	n	7e	~
0f	si	1f	us	2f	/	3f	?	4f	O	5f	_	6f	o	7f	del

Your old friend is back! ASCII!!

The contents of a file:

ex1_ascii_file.txt



19 Characters (including spaces)

19 bytes!

A Text Editor can gladly interpret this bunch of binary #s

ASCII Files (aka Text Files)

Text editors:

- Windows notepad, unix vi, emacs, etc.
  - They look at every byte and attempt to map it to ASCII
  - They only show ASCII representation of the binary underneath
  - Programmer's give these files meaningful extensions:
    - .TXT, .C, .JAVA, .ASM, etc.
    - Means that binary contents of the file can be mapped to ASCII

- You can't open an ASCII file in its true binary form!
  - Editors want to convert it to ASCII first
  - Can see binary form with tools:
    - Handy tools: hexdump, od, (there are many)

ASCII is one way…

Why can't we make another?

- In fact, programmers do it all the time!
  - .jpg, .doc, .ppt, .xls, .exe, .class, .obj, .o, and on and on!
- We refer to these as binary files
  - Because their binary representation can't be mapped to ASCII
- Programmers simply makeup a format:
  - And then stick to it!
  - Ex: when MS-Word encounters a .doc file
    - Only it understands the made-up binary format
    - Much like an ASCII editor, word doesn't show you the binary underneath, it maps each byte to its own meaning

A wonderful example of a non-ASCII file format:

PennSim takes in an ASCII file: (.ASM)

- **Assembles it and produces a binary: .OBJ file**
  - **That .OBJ file isn't just the binary equivalent of the .ASM**
  - **It is a format that instructs PennSim how to fill up memory**
  - **We made it up!**

- **If we close PennSim and re-open it,**
  - **We may reload the .OBJ file**
  - **And memory will fill up just the same way**
  - **We no longer need the original .ASM file**

A wonderful example of a non-ASCII file format:

PennSim's .OBJ file format explained:

- **Breaks down into 5 sections**
  - ➢ **We call the beginning of each section a header**
    1. **CODE section**
       - **Maps to the .CODE directive (your code)**
    2. **DATA section**
       - **Maps to the .DATA directive (initial data values)**
    3. **SYMBOL section**
       - **Maps to the LABELS you create in your assembly code**
    4. **FILENAME section**
       - **Maps to the name of the .C file(s) assembly came from**
    5. **LINE NUMBER section**
       - **Tells you which assembly lines came from which .C file**
- ***These sections can repeat over and over***

A wonderful example of a non-ASCII file format:

PennSim's .OBJ file format explained:

- The header tells us how long each section is
  - Each header has its own format:
    1. CODE header (3 word header = 3 x 16 header)
       - Format: `xCADE, <address>, <n=#words> (16-bits each)`
    2. DATA header (3 word header = 3 x 16 header)
       - Format: `xDADA, <address>, <n=#words> (16-bits each)`
    3. SYMBOL header: (3 word header = 3 x 16 header)
       - Format: `xC3B7, <address>, <n=#bytes> (16-bits each)`
    4. FILENAME header: (2 word header = 3 x 16 header)
       - Format: `xF17E, <n=#bytes>  (16-bits each)`
    5. LINE NUMBER header: (3 word header = 3 x 16 header) *– no body*
       - Format: `x715E, <address>, <line>, <file-index>`
  - The <n> in each header, tells us length of the section

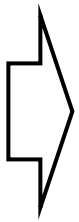
Example: .ASM->.OBJ->Format Explained

file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```



file_format_example.obj

```
CA DE 00 00 00 02
90 02 10 00 DA DA
40 00 00 01 00 00
C3 B7 40 00 00 05
4D 59 56 41 52 C3
B7 00 00 00 06 4C
41 42 45 4C 31
```

Appears to be a random dump of hex #s

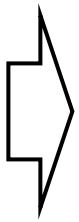
Example: .ASM->.OBJ->Format Explained

file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```



file_format_example.obj

```
CA DE 00 00 00 02
90 02 10 00 DA DA
40 00 00 01 00 00
C3 B7 40 00 00 05
4D 59 56 41 52 C3
B7 00 00 00 06 4C
41 42 45 4C 31
```

Until we assign meaning!

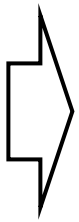
Example: .ASM->.OBJ->Format Explained

file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```



file_format_example.obj

```
CADE 0000 0002
90 02 10 00
DADA 4000 0001
00 00
C3B7 4000 0005
4D 59 56 41 52
C3B7 0000 0006
4C 41 42 45 4C 31
```

First, look for the headers

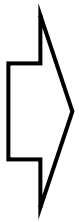
Example: .ASM->.OBJ->Format Explained

file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```



file_format_example.obj

```
CADE 0000 0002
90 02 10 00
DADA 4000 0001
00 00
C3B7 4000 0005
4D 59 56 41 52
C3B7 0000 0006
4C 41 42 45 4C 31
```

Next, interpret them!

Example: .ASM->.OBJ->Format Explained

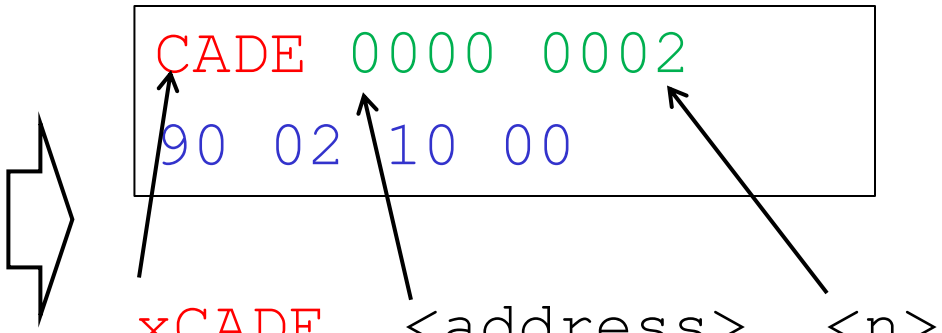
file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```

file_format_example.obj




```
.CODE
x0000
n=2
```

means, next 2-words are at ADDRESS 0000

Example: .ASM->.OBJ->Format Explained

file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```

file_format_example.obj

```
CADE 0000 0002
90 02 10 00
```

xCADE, <address>, <n>

What are the next 2 words?

9002 = 1001 000 000000010

CONST RD IMM9

1000 = 0001 000 000 000 000

ADD Rd Rs Rt

Example: .ASM->.OBJ->Format Explained

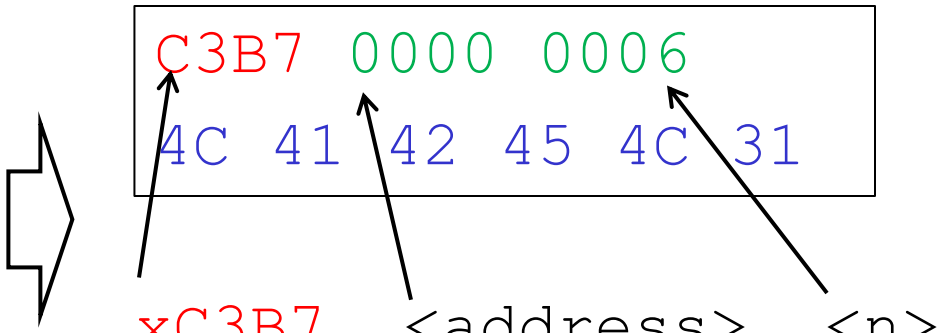
file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```

file_format_example.obj




```
.C3B7
x0000
n=6
```

means, next 6-bytes are ASCII label for address x0000

Example: .ASM->.OBJ->Format Explained

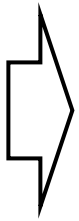
file_format_example.asm

```
.CODE
.ADDR x0000

LABEL1
  CONST R0, #2
  ADD R0, R0, R0

.DATA
.ADDR x4000
  MYVAR .BLKW x1
```

file_format_example.obj



```
C3B7 0000 0006
4C 41 42 45 4C 31
```

xC3B7, <address>, <n>

What are the next 6 bytes?

4C 41 42 45 4C 31

ASCII Equivalent:

L A B E L 1

Example: .ASM->.OBJ->Format Explained

The breakdown of the rest of the .OBJ sections

- **Is given in the HW**
- **This was just meant to give you a sample of how they work**

1 Little, 2 Little, 3 Little…

What is ENDIANNESS?

- Refers to how the binary data in a file is ordered
- 2 types of ENDIANNESS conventions

BIG ENDIAN FILES:

- Bytes are stored in file from MSB to LSB
- Example: `CADE 0000 0002`

LITTLE ENDIAN FILES:

- Bytes are stored in file from LSB to MSB
- Example: `DECA 0000 0200` (*notice bytes are swapped*)

From one OS to another you can encounter this swap

- Windows->Unix, sometimes encounter trouble!

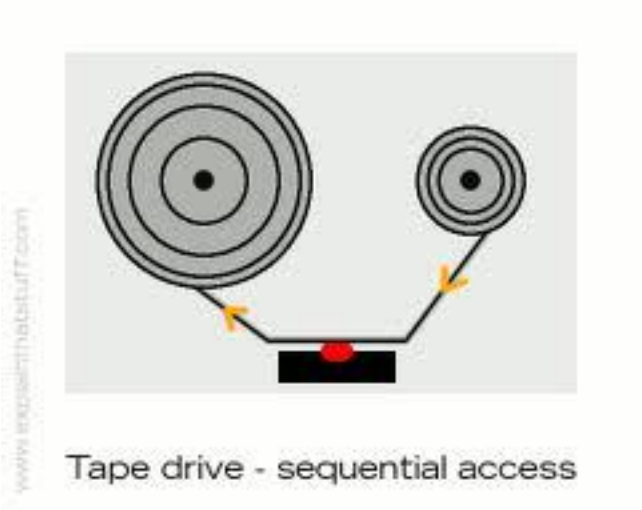
OVERVIEW - FILES IN C

An Important Metaphor

- **Files were developed to model sequential access devices like magnetic tape drives.**
- **The basic operations on files make sense in this context**

Basic File operations

- **Opening a file for reading or writing**
  - **Read/Write head positioned at the start of the file**
- **Read/Write an element to the file**
  - **Advancing the read/write head by the number of bytes read or written.**
- **Rewind**
  - **Rewind file to the start**
- **Seek**
  - **Seek to a specific position in the file**



Files

In C files are very simple objects – they simply consist of a sequence of bytes. Any interpretation that we ascribe to those bytes is up to the programs we write.

- **Basic operations on files**
  - **Open**
  - **Close**
  - **Read**
  - **Write**
- **Files usually exist within the context of a file system which provides an overall context for organizing and naming the files**

C treats files in two ways: text or binary

Two basic types

Text (aka ASCII) files: plain printable text

- **Generally human readable and editable**
- **Readable/writeable a byte at a time (since ASCII needs 8-bits)**

Binary files: everything else

- **Kind of a misnomer (is ASCII not binary?)**
- **Generally not human readable and editable (looks like garbage)**
- **Readable/writeable in multiple bytes at a time**

Modeling I/O as File Access

- **In the UNIX operating system I/O devices were modeled as files, you could open them, write bytes to them and/or read bytes from them.**
- **This made sense in the context of the I/O devices of the time which did in fact work that way – like tape drives, keyboards, and ASCII terminals.**

USEFUL FUNCTIONS TO WORK WITH FILES IN C

C functions to open/close & read/write to files

fopen()

fclose()

- ***Allow us to open/close a file***

fgetc()

fputc()

- ***Allow us to read/write 1 character (aka a byte) from/to a file***

fgets()

fputs()

- ***Allow us to read/write 1 line (as a string) from/to a file***

fread()

fwrite()

- ***Allow us to read/write multiple bytes from/to a file***

example:

READ/WRITE BYTE AT A TIME

Function: FOPEN()

Purpose: ***helper function open up a file***

Function declaration:

FILE* fopen (const char *filename, const char *mode)

2 Arguments:

filename **– a string containing name of the file in the filesystem**

mode **– a string containing the type of file access (read/write/etc)**

- **"r" – open file for reading**
- **"w" – open file for writing**
- **"a" – append to file – if file exists add stuff at the end**
- **"rb" – open binary file for reading**
- **"wb" – open file for binary output**

Return:

- **If file doesn't exist/can't be created: NULL is returned**
- **Otherwise, a pointer to the open FILE is returned**

Type: FILE

Purpose: a datatype that holds information about an open file

- ***Information like: place in filesystem, our position in the file, etc.***

Details:

- ***Operating System dependent!***
- ***Not a structure we ever actually probe, we use file helper functions to interact with it***

Example Structure declaration:

```
typedef struct {
    short int level ;
    short int token ;
    short int bsize ;
    char fd ;
    unsigned int flags ;
    unsigned char hold ;
    unsigned char *buffer ;
    unsigned char * curp ;
    unsigned int istemp;
} FILE ;
```

Function: FGETC()

Purpose: ***reads character from a file and advances "position indicator"***

Function declaration:

int fgetc (FILE* *stream*)

1 Argument:

***stream* – The pointer to an open file one wishes to read a character from**

Return:

- **Returns a byte (1 character) read from the file as an integer**
- **If the file is at its end, it returns: EOF**
  - ***EOF is typically: -1 ; it indicates end of file has been reached***

Example:

Calling it once get's first byte, calling it again gets you the next byte!

Function: FPUTC()

Purpose: ***writes character to a file and advances "position indicator"***

Function declaration:

int fputc (int character, FILE* *stream*)

2 Argument:

character **– The character (byte) to be written**

stream **– The pointer to an open file one wishes to read a character from**

Return:

- **If no error occurs, returns the same character that has been written**
- **If an error occurs, returns EOF**

Question…what is EOF?

- **#define EOF -1 /* could be different # on different systems*/**
- ***Basically a constant that is used to indicate the end of a file***

Example of fgetc & fputc

```
#include <stdio.h>

/* this code will copy a file byte by byte */

int main () {
  FILE *src_file, *des_file ;
  int byte_read ;

  src_file =fopen ("file_format_ex.obj", "rb");
  if (src_file == NULL) { return 1 ; }

  des_file =fopen ("file_format_ex_cp.obj", "wb");
  if (des_file == NULL) { fclose (src_file) ; return 2 ; }
```

Example of fgetc & fputc (con't)

```
  do {
      byte_read = fgetc (src_file) ;
      if (byte_read == EOF) break ;

      fputc (byte_read, des_file) ;
  }  while (1) ;

  fclose (src_file) ; /* flcose() returns 0 if file closes */
  fclose (des_file) ; /* otherwise returns EOF on failure  */

  return 0 ;
}
```

What does this program do?

Makes a copy of a file, one byte at a time!

example:

READ/WRITE TO AN ARRAY

Function: FREAD()

Purpose: ***reads data from a file into an array***

Function declaration:

size_t fread (void *ptr, size_t size, size_t nmemb, FILE *stream)

note: size_t is a typically a typedef'ed "unsigned int"

4 Arguments:

ptr **– a pointer (of any type) to array you want to read data into**

size **– size (in bytes) of a single element of your array**

nmemb **– the total number of elements in your array**

stream **– pointer to an open file to read from**

Return:

- **The total number of elements successfully read**
- **If this number is different from *nmemb* parameter, you've hit EOF or an error occured**

Function: FWRITE()

Purpose: ***writes data from an array into a file***

Function declaration:

size_t fwrite (const void *ptr, size_t size, size_t nmemb, FILE *stream)

note: size_t is a typically a typedef'ed "unsigned int"

4 Arguments:

ptr **– a pointer (of any type) to array you want write data from**

size **– size (in bytes) of a single element of your array**

nmemb **– the total number of elements in your array**

stream **– pointer to an open file to write to**

Return:

- **The total number of elements successfully written**
- **If this number is different from *nmemb* parameter an error has occured**

Example of fwrite to write data from an array

```
#include <stdio.h>
#define ARRAY_SIZE 4
int main ()
{
  int num1 = 0xFEDC ;      // A single HEX integer
  int array[ARRAY_SIZE]={0, 1, 2, 3} ;    // A integer array
  FILE *theFile = fopen ("output_file", "wb"); // test me!

  // write out the whole array of ints
  fwrite (array, sizeof(int), ARRAY_SIZE, theFile);

  // write out just a single int!
  fwrite (&num1, sizeof(int), 1, theFile);

  fclose (theFile);
  return 0;
}
```

Why won't this example work?

```
#include <stdio.h>
int main ()
{

  int* array ;
  FILE *theFile = fopen ("input_file", "rb"); // test me!

  // read in an array of ints
  fread (array, sizeof(int), 10, theFile);

  fclose (theFile);
  return 0;
}
```

It will definitely compile! But it will crash right on fread()…why?

"array" is a pointer that points to nothing

How to fix?

Allocate memory to the pointer!

This is one way to fix (using memory on the stack)

```
#include <stdio.h>
int main ()
{

  int array[10] ; // allocate memory on the stack first!
  FILE *theFile = fopen ("input_file", "rb"); // test me!

  // read in an array of ints
  fread (array, sizeof(int), 10, theFile);

  fclose (theFile);
  return 0;
}
```

This is another way to fix (using memory on the HEAP)

```
#include <stdio.h>
#include <stdlib.h>
int main ()
{
  int* array ;
  FILE *theFile = fopen ("input_file", "rb"); // test me!

  // allocate memory on the heap first!
  array = malloc (sizeof(int) * 10 ) ; // test me!

  // read in an array of ints
  fread (array, sizeof(int), 10, theFile);
  free (array) ;   // release heap memory
  fclose (theFile);
  return 0;
}
```

example:

READ/WRITE STRINGS

Function: FGETS()

Purpose: ***reads a string from a file***

Function declaration:

char* fgets (char* *str*, int *n*, FILE* *stream*)

3 Arguments:

str **– a pointer to an array of chars to read string into**

n **– the maximum # of characters to be read from file (including NULL)**

stream **– pointer to an open file to read from**

Return:

- **On success: function returns pointer to *str***
- **On failure: NULL pointer is returned**

Function: FPUTS()

Purpose: ***writes a string to a file***

Function declaration:

char* fputs (const char* *str*, FILE* *stream*)

3 Arguments:

***str* – a pointer to array containing NULL terminated string**

***stream* – pointer to an open file to written to**

Return:

- **On success: returns a non-negative value**
- **Otherwise returns EOF**

Example of fputs to write data from an string

```
#include <stdio.h>
#define ARRAY_SIZE 4
int main ()
{
  char array[ARRAY_SIZE]={'T','o', 'm', '\0'} ;
  char* array2 = "Tom" ;
  FILE *theFile = fopen ("output_file.txt", "w"); // test me!

  fputs (array,  theFile) ; // why don't I need array size?
                            // fputs writes until it hits NULL
  fputs (array2, theFile) ; // write out char*
  fputs ("Tom", theFile) ;  // write out string literal

  fclose (theFile);
  return 0;
}
```

This code compiles, but crashes…why?

```
#include <stdio.h>
int main ()
{
  char* array1 ;
  char* array2 = "Tom" ;
  char  array3 [3] ;
  FILE *theFile = fopen ("input_file.txt", "r"); // test me!

  fgets (array1, 4, theFile) ; // this will fail!
  fgets (array2, 4, theFile) ; // this too will fail!
  fgets (array3, 4, theFile) ; // and this one too…why?

  fclose (theFile);
  return 0;
}
```

Array1 points to nothing – must allocate memory

Array2 is considered a constant – can't change literals!

Array3 doesn't have enough length

example:

READ/WRITE FORMATTED STRINGS

Function: FPRINTF()

Purpose: ***writes formatted string to a file***

Function declaration:

int fprintf (FILE* *stream*, const char* *format*, ...)

2… Arguments:

***stream* – pointer to an open file to read from**

***Format* – the "formatted" string to be written to the file**

… - optionally the formatted string can embed format tags, replaced with these extra arguments

Return:

- **On success: total number of characters written**
- **On failure: a negative number is returned**

Example of fprintf to write out a formatted string

```
#include <stdio.h>
int main ()
{
  int a = 5 ;
  char* string = "World" ;
  FILE *theFile = fopen ("output_file.txt", "w"); // test me!

  fprintf (theFile, "Hello World\n") ;
  fprintf (theFile, "Hello %s\n", string) ;
  fprintf (theFile, "a = %d\n", a) ; // prints in decimal
  fprintf (theFile, "a = %x\n", a) ; // prints in hex
  fprintf (theFIle, "a's address = %p\n", &a) ;
                                    // prints out a's add.

  fclose (theFile);
  return 0;
}
```

stdin, stdout, and stderr

C library defines three “constant” file handles

- **Constant? always open, cannot close**
- **stdin: standard-input (console)**
- **stdout: standard-output (console, for output)**
- **stderr: standard-error (console, for error message)**
- **printf(“hi\n”); equivalent to fprintf(stdout,“hi\n”);**

Using fprintf() like its good old printf()

```
#include <stdio.h>
int main ()
{
  int a = 5 ;
  char* string = "World" ;

  fprintf (stdout, "Hello World\n") ; // prints to screen!
  fprintf (stderr, "Error has occurred!\n") ;
                   // prints to admin's console

  return 1;        // indicates error has occured
}
```

Function: FSCANF()

Purpose: ***reads formatted string from a file***

Function declaration:

int fscanf (FILE* *stream*, const char* *format*, ...)

2… Arguments:

***stream* – pointer to an open file to read from**

***Format* – the "formatted" string to be read to w/formatting tags**

Return:

- **On success: returns # of items successfully matched and assigned**
- **On failure: less than you expected indicates error has occured**

Using fprintf() like its good old printf()

```
#include <stdio.h>
int main ()
{
 char str1[10], str2[10];
 int year, match ;
 FILE *theFile = fopen ("input_file.txt", "r"); // test me!

 match=fscanf(theFile, "%s %s %d", str1, str2, &year);
 printf ("Read in %d items from file", match) ; // prints 3

 fclose (theFile) ;
}
```

If text file contained: "I love 1980"

str1="I"

str2="love"

year = 1980

MORE COMPLEX EXAMPLE!

Using fgets and fscanf to read & parse strings…

```
#include <stdio.h>
#include <string.h>

#define MAX_LINE_LENGTH 80

int main ()
{
  int i, num1, num2;
  char input[MAX_LINE_LENGTH];
  char fname[MAX_LINE_LENGTH];

  printf ("Enter command: SCRIPT <filename>,
           SET R<number> <value>, EXIT\n") ;
```

Using fgets and fscanf to read & parse strings…

```
 /* now we drop into a loop and read string from keyboard */
while (fgets (input, MAX_LINE_LENGTH, stdin)) {
    printf ("\nString Read In: %s\n", input);

    if (sscanf (input, "SCRIPT %s", fname) == 1)
      printf ("It's a SCRIPT command - fname = %s\n", fname);

    if (sscanf (input, "SET R%d %d", &num1, &num2) == 2)
      printf ("It's a SET command :
               Set register %d to 0x%x\n", num1, num2);

    if (strcmp (input, "EXIT\n") == 0 ) {
        printf ("Exiting loop") ;
        break ;
    }
    printf ("################################\n");
}
```

C functions to tell us our position in a file

EOF

- **At the end of the file? Returns 1 if yes**

int feof(FILE *f);

- **At the end of the file? Returns 1 if yes**

void rewind(FILE *f);

- **Be kind**

long int ftell(FILE *f);

- **Returns current position in file, -1 if an error occurs**

void fseek(FILE *f, long int offset, int origin);

- **advances position in file: offset + origin**

argc and argv

The two default arguments to main recall C's roots in Unix. They are used to pass command line arguments to a program.

- **int main (int argc, char **argv)**
- **argc – number of 'words' on the command line (argc >= 1)**
- **argv – list of strings containing all of these words**
  - **Note the declaration of argv as a pointer to an array of pointers – double dereferencing.**

Example:

```
int main (int argc, char **argv) {
  int i;
  for (i = 0; i < argc; ++i)
    printf ("Argument %d = %s\n", i, argv[i]);
}
```