CPS 188

Computer Programming Fundamentals

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Topic 10.2: Struct example, binary file I/O

Toronto Metropolitan University

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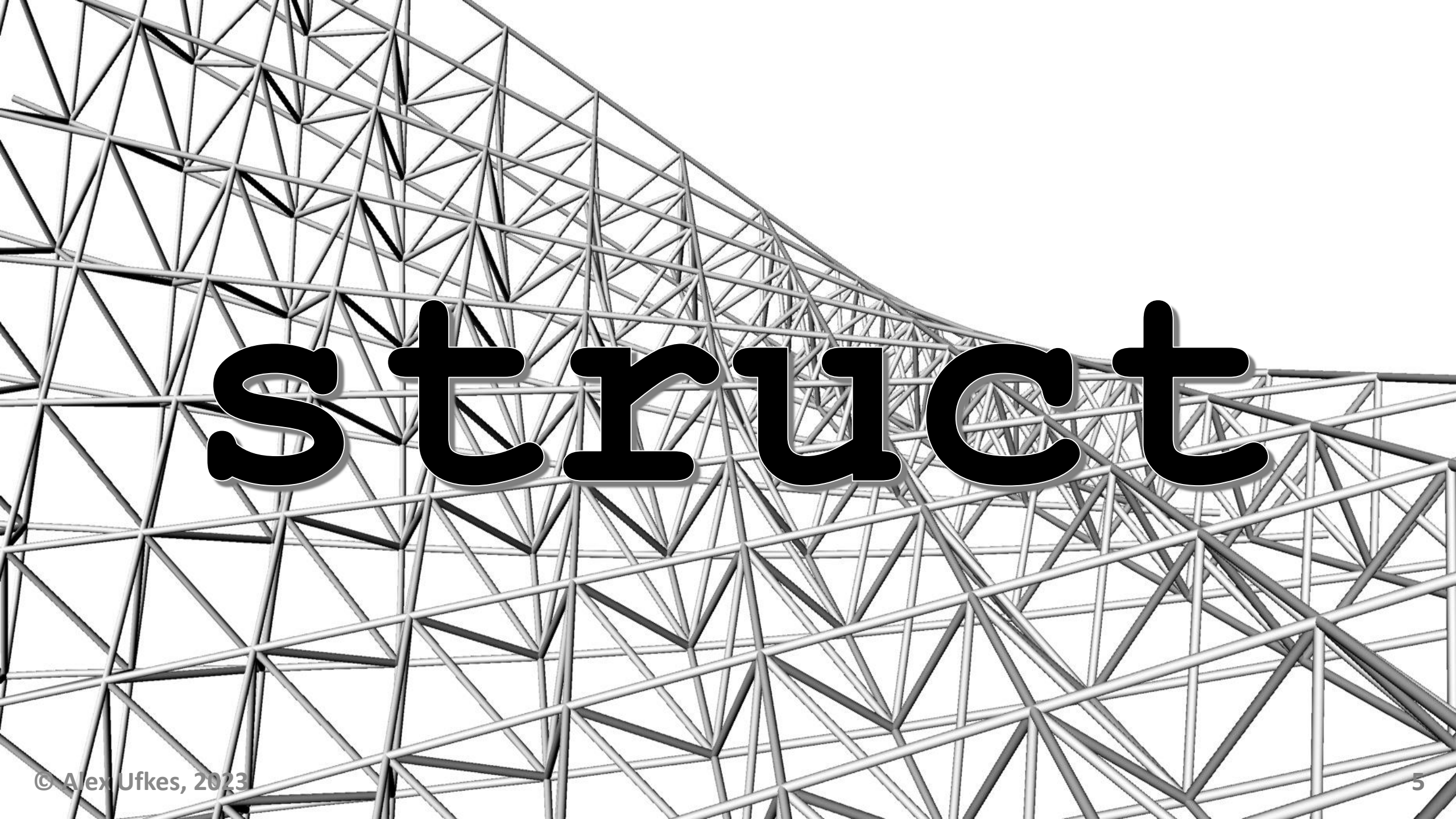
Notice!

Final exam info posted on D2L.

Check the announcement!

Previously…



Structs

A collection of variables, types can vary

```
struct ball
{
    char style[10];
    double radius;
    double weight;
};
```

```
struct ball
{
    char style[10];
    double radius;
    double weight;
};

int main()
{
    struct ball b1, b2, b3, b[50];

}
```

`struct` variable declaration

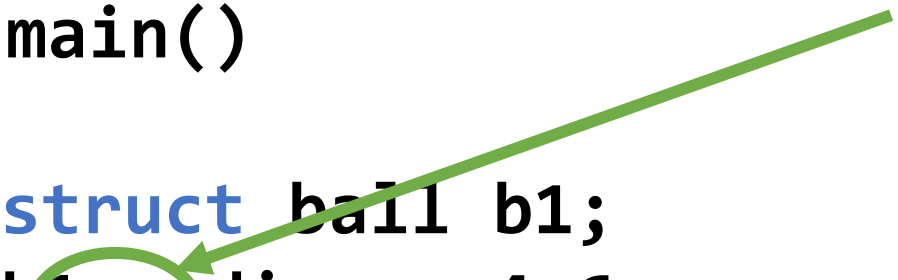
Or as an array

Declare individually

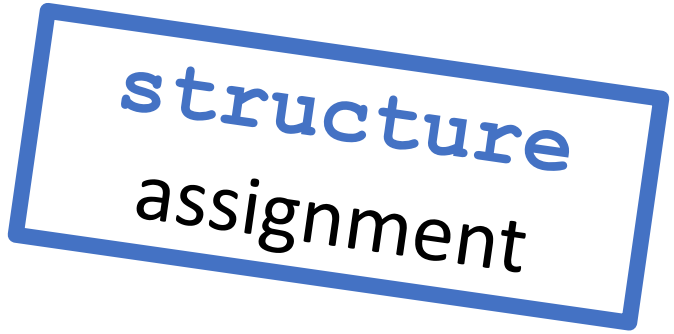
Accessing `struct` members

```
struct ball
{
    char style[10];
    double radius;
    double weight;
};

int main()
{
    struct ball b1;
    b1.radius = 4.6;
    b1.weight = 22.1;
    strcpy(b1.style, "Wilson");
}
```



Use the dot operator to access a struct's individual variables.




```
struct1 = struct2;
```

Assigns one struct to another

Assuming the same structure type

All member variable values are copied!

typedef

Create an Alias

```
#include <stdio.h>

typedef int integer;

int main()
{
    integer x, y, z;
    x = 1;
    y = 2;
    z = x + y;
}
```

Create "integer" alias for type int

`integer` can now be used as a type! It's the same as `int`, except for the name.

Common for Structures

```
typedef struct ball
{
    char style[10];
    double radius;
    double weight;
} ball;
```

Now, instead of declaring:

```
struct ball b1, b2, b3;
```

We can simply declare:

```
ball b1, b2, b3;
```

Common for Structures

Alias can be different from struct name:

```
typedef struct ball
{
    char style[10];
    double radius;
    double weight;
} basketball;
```

Declaration:

```
basketball b1, b2, b3;
```

Can still declare:

```
struct ball a, b, c;
```

```
typedef struct ball
{
    char style[10];
    double radius;
    double weight;
} basketball;

int main()
{
     basketball b1 = {“Wilson”, 3.4, 6.8};
     return 0;
}
```

Declare and Initialize

Order must match structure definition

Structures & Functions

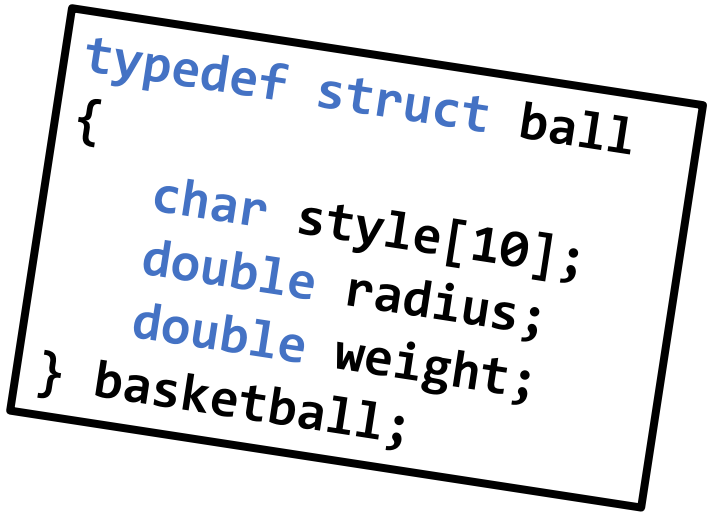
Structures passed as input to a function are **COPIED** into the corresponding function parameter. All member variables are copied as well.

This is **DIFFERENT** from arrays, which are **NOT** copied. Only the base address of the array is copied, not the elements.

Write a user-defined function that does the following:

Takes in zero arguments, and returns a `basketball` struct.
The function will ask the user to enter values for each of `basketball`'s member variables.

```
basketball readElements(void)
{
    basketball b;
    printf("Enter the style: ");
    scanf("%s", b.style);
    printf("Enter the radius: ");
    scanf("%lf", &b.radius);
    printf("Enter the weight: ");
    scanf("%lf", &b.weight);
    return b;
}
```



```
basketball readElements(void)
{
        basketball b;
        printf("Enter the style: ");
        scanf("%s", b.style);
        printf("Enter the radius: ");
        scanf("%lf", &b.radius);
        printf("Enter the weight: ");
        scanf("%lf", &b.weight);
        return b;
}
```

```
void printElements(basketball b)
{
    printf("Style:  %s\n", b.style);
    printf("Radius: %lf\n", b.radius);
    printf("Weight: %lf\n", b.weight);
}
```

It is possible to return an entire `struct`. ***Unlike*** arrays, ALL values are copied.

```
int main()
{
        basketball b1 = readElements();
        printElements(b1);
        return 0;
}
```

Pass a pointer:

```
typedef struct foo {
    int a, b;
} foo;
```

```
void swap(foo input)
{
    int tmp = input.a;
    input.a = input.b;
    input.b = tmp;
}
```

```
void swap(foo *input)
{
    int tmp = input->a;
    input->a = input->b;
    input->b = tmp;
}
```

If `input` is a ***pointer*** to a struct, we use the **arrow operator (->)** instead of the dot operator.

```
void swap(foo *input)
{
    int tmp = input->a;
    input->a = input->b;
    input->b = tmp;
}

int main()
{
     foo f1 = {1, 2};
     printf("Before swap: %d %d\n", f1.a, f1.b);
     swap(&f1);
     printf("After swap:  %d %d", f1.a, f1.b);
     return 0;
}
```

What is the output?

```
Before swap: 1 2
After swap:  2 1
```

We can also dereference!

```
void printElements(basketball *b)
{
    printf("Style:  %s\n",  b->style);
    printf("Radius: %lf\n", b->radius);
    printf("Weight: %lf\n", b->weight);
}
```

```
typedef struct ball
{
    char style[10];
    double radius;
    double weight;
} basketball;
```

Is the same as:

```
void printElements(basketball *b)
{
    printf("Style:  %s\n",  (*b).style);
    printf("Radius: %lf\n", (*b).radius);
    printf("Weight: %lf\n", (*b).weight);
}
```

Must use parentheses (*b) otherwise the dot operator is applied first

Example: Complex Number

$$\sqrt{-1}$$

Example: Complex Number

```
typedef struct complex
{
    double real;
    double imag;
} complex;
```

Complex Number: Scanning

```
complex scan_complex ()
{
    complex c;

    printf("Enter real component: ");
    scanf("%lf", &c.real);
    printf("Enter imaginary component: ");
    scanf("%lf", &c.imag);

    return (c);
}
```

Complex Number: Printing

```
void print_complex (complex c)
{
    printf("%.2lf", c.real);
    if (c.imag >= 0.0)
        printf("+");
    printf("%.2lfi", c.imag);
}
```

Complex Number: Adding

Return a new complex number, whose components
are the sum of the operands:

```
complex add_complex (complex op1, complex op2)
{
    complex sum;
    sum.real = op1.real + op2.real;
    sum.imag = op1.imag + op2.imag;
    return sum;
}
```

Complex Number: Subtracting

Return a new complex number, whose components are the difference of the operands:

```
complex sub_complex (complex op1, complex op2)
{
    complex diff;
    diff.real = op1.real - op2.real;
    diff.imag = op1.imag - op2.imag;
    return diff;
}
```

Complex Number: Absolute Value

Hypotenuse between real and imaginary magnitudes:

```
complex abs_complex (complex c)
{
    complex res;
    res.real = sqrt(c.real*c.real + c.imag*c.imag);
    res.imag = 0;
    return res;
}
```

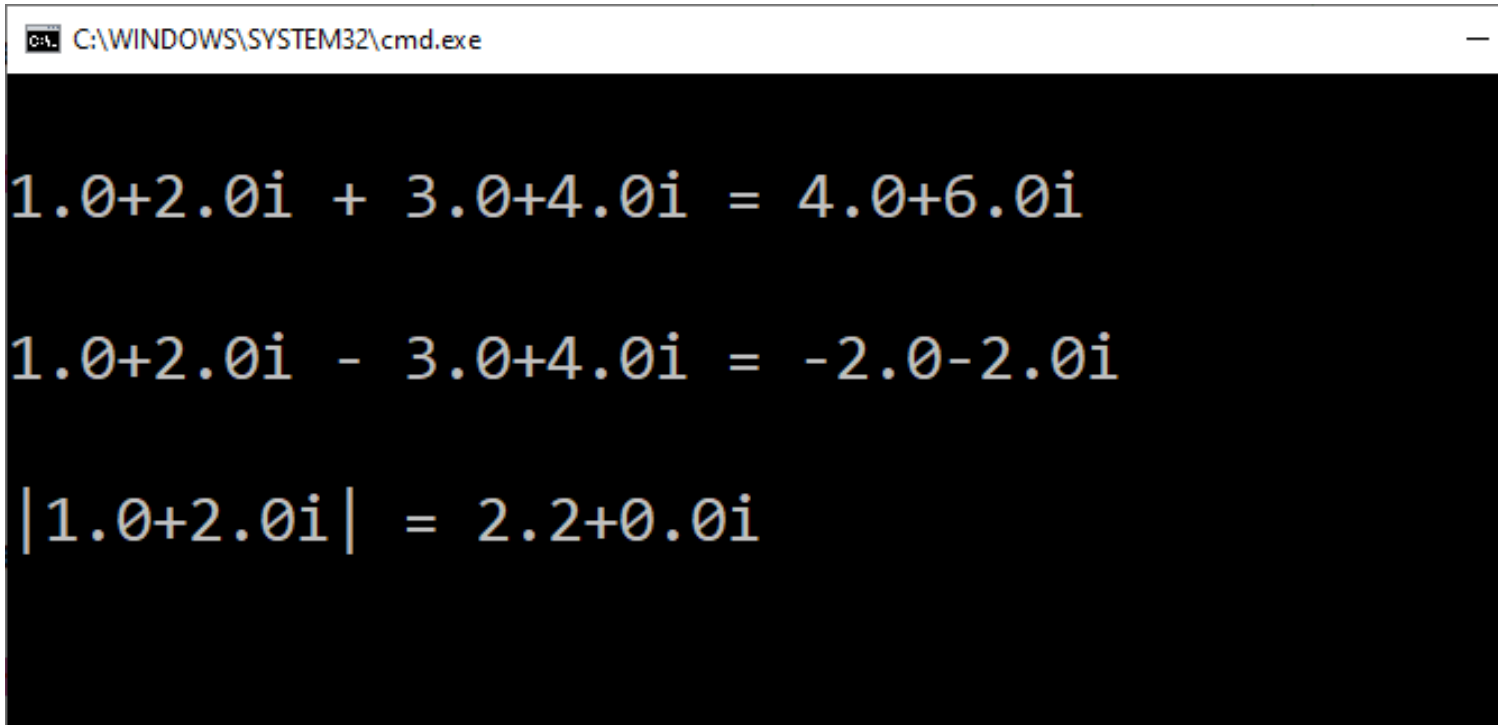
```
int main (void)
{
    complex c1 = {1, 2};
    complex c2 = {3, 4};

    /* Forms and displays the sum */
    printf("\n");
    print_complex(c1);
    printf(" + ");
    print_complex(c2);
    printf(" = ");
    print_complex(add_complex(c1, c2));

    /* Forms and displays the difference */
    printf("\n\n");
    print_complex(c1);
    printf(" - ");
    print_complex(c2);
    printf(" = ");
    print_complex(sub_complex(c1, c2));

    /* Forms and displays the absolute value of the first number */
    printf("\n\n|");
    print_complex(c1);
    printf("| = ");
    print_complex(abs_complex(c1));
    printf("\n");

    return (0);
}
```



Binary File IO

Binary VS ASCII

- Up to now, we've dealt exclusively with plain text files.
- Integers are read in the form of digit strings and converted internally.
- A text file containing **123456789** doesn't contain the *integer* 123456789.
- It contains the *digit characters* **'1'**, **'2'**, **'3'**, and so on.

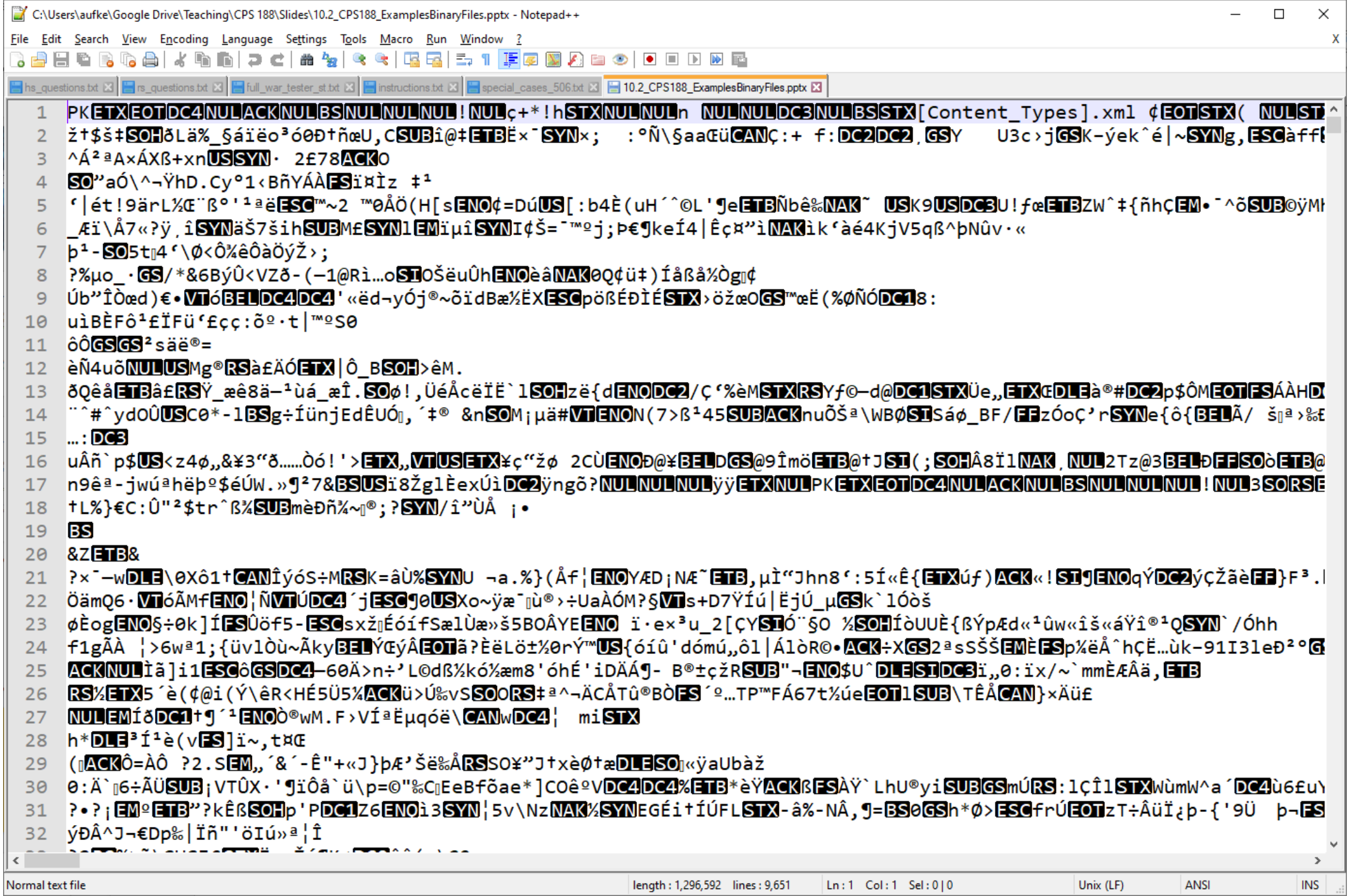
This is inefficient!

- Nine characters require 9 bytes of storage.
- 123456789 can also fit in an `int`, requiring only *four* bytes.
- Why not store this number as a binary, two's complement integer instead?

Binary Files

This will come with a downside!

- Plain text files are nice, because they are human-readable.
- A binary file is not. Its contents do not convert to readable ASCII characters.
- However, we can store information much more efficiently.
- This is why plain text files are actually very uncommon in commercial applications.
- Try opening a PDF, docx, excel spreadsheet, etc. as plain text.
- You get gibberish, because these file types use a different binary encoding.


C:\Users\aufke\Google Drive\Teaching\CPS 188\Slides\10.2_CPS188_ExamplesBinaryFiles.pptx - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Window ?
hs_questions.txt
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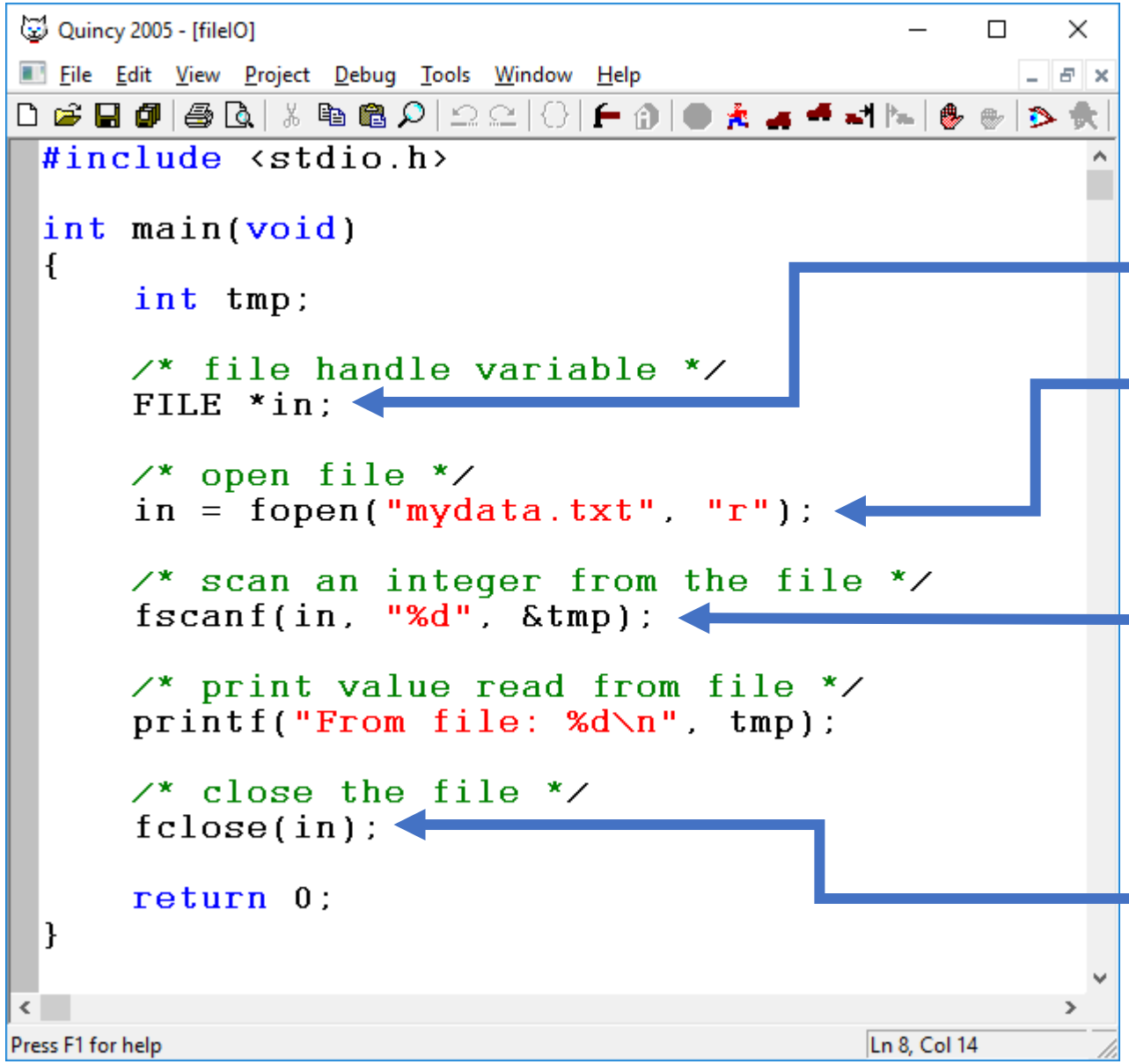
?•?¡ EM º ETB ”?kÊß SOH p'P DC1 Z6 ENO ì3 SYN ¦5v\Nz NAK ½ SYN EGÉi†ÍÚFL STX -â%-NÂ,¶=BS0 GS h*Ø>ESC frÚ EOT zT÷ÂüÏ¿þ-{'9Ü þ¬ FS
ýÐÂ^J¬€Dp‰|Ïñ"'öIú»ª¦Î
Normal text file
length : 1,296,592 lines : 9,651
Ln : 1 Col : 1 Sel : 0 | 0
Unix (LF)
ANSI
INS

fscanf



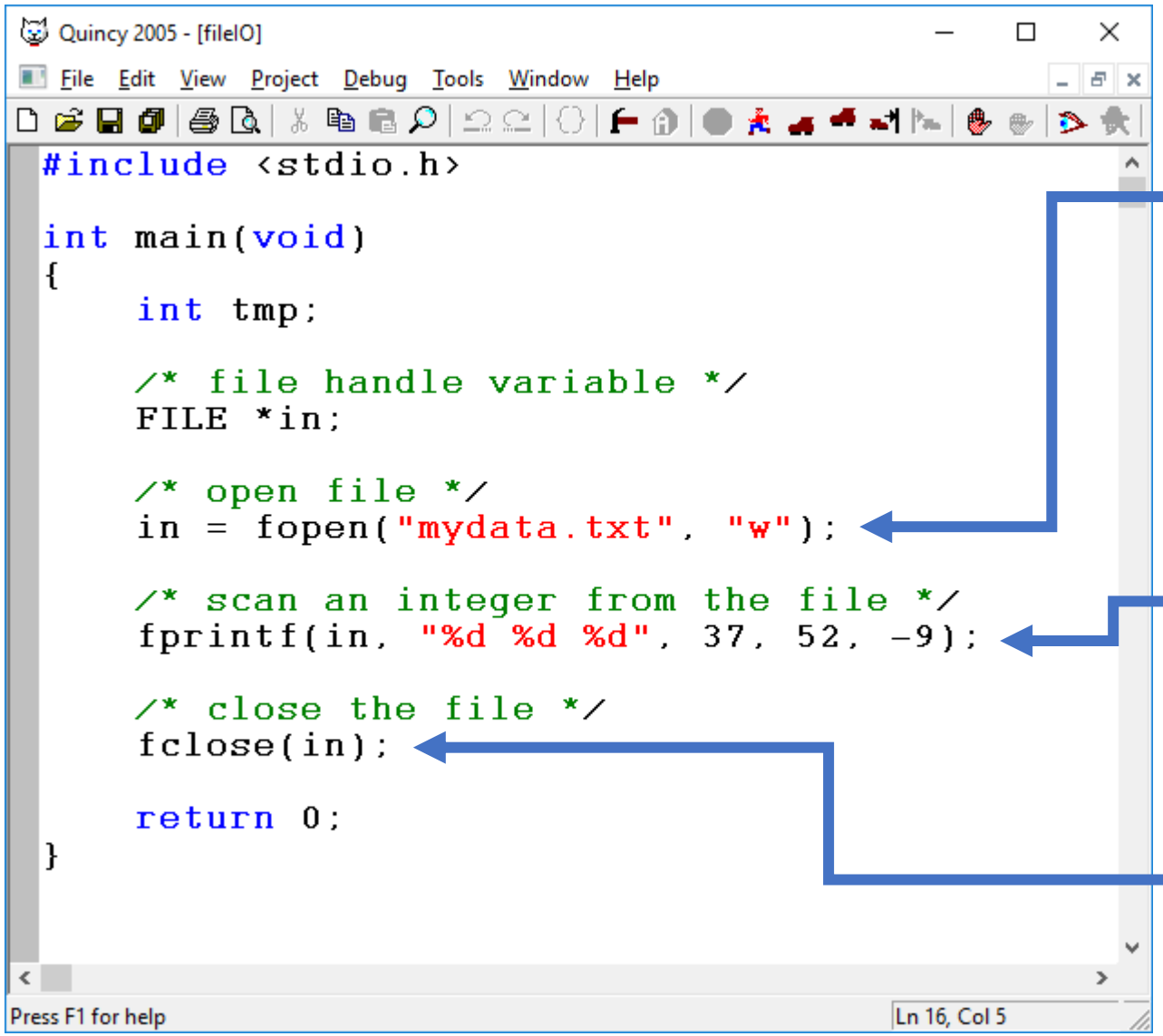
New variable type: FILE *

fopen to open the file. First argument is the filename, second is the mode. **"r"** means ***read***.

fscanf - Like scanf but takes an argument before the string: the file handle variable.

fclose – File should be closed once we're done with it.

fprintf



Must first open the file:

- This time we're ***writing***. "w" means write.
- ***If the file already exists, it will be overwritten!***

fprintf - Like printf but takes an argument before the string: the file handle variable.

fclose – File should be closed once we're done with it.

Read Binary, Write Binary

We still use **fopen**, but this time the 2nd argument is different:

```
fopen("data.bin", "wb");
```

"wb" for write binary

```
fopen("data.bin", "rb");
```

"rb" for read binary

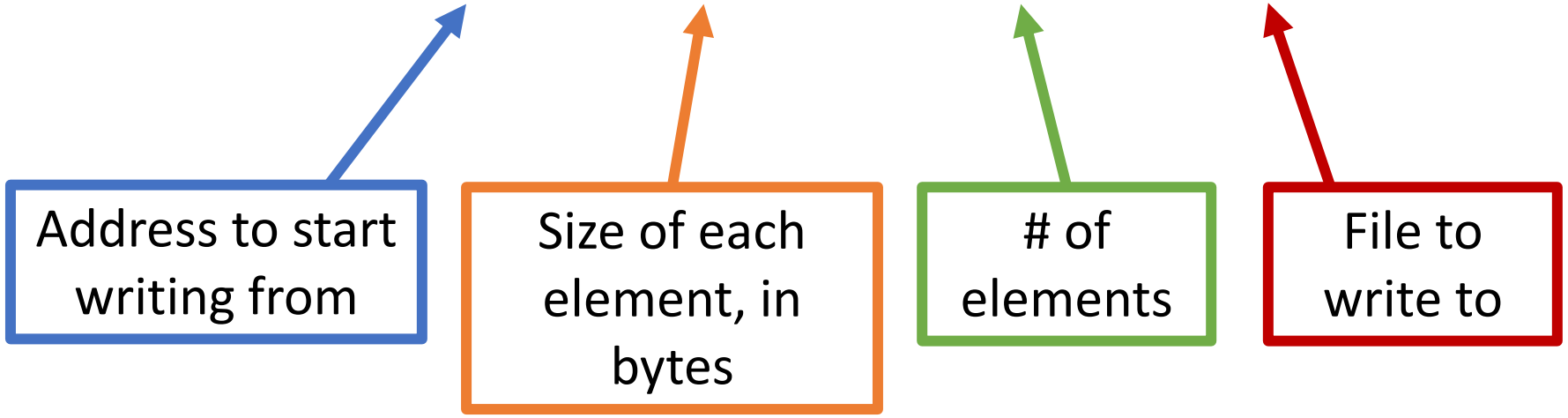
File extension?

- For binary files, **.dat** is common, as is **.bin**
- Extension doesn't matter! We can read the bits in a file however we want.

Read Binary, Write Binary

We no longer use **`fprintf`** or **`fscanf`**:

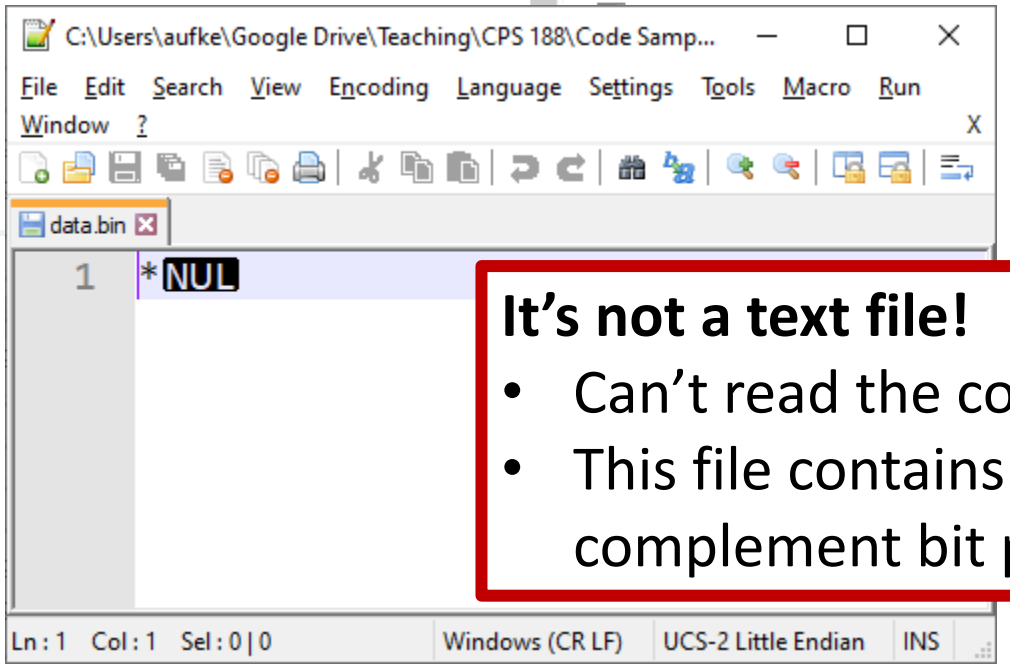
```
FILE* bin_out;
bin_out = fopen("data.bin", "wb");
int x = 42
fwrite(&x, sizeof(x), 1, bin_out);
```



binaryIO.c

```c
#include <stdio.h>

int main (void)
{
    FILE* bin_out = fopen("data.bin", "wb");

    int x = 42;

    fwrite(&x, sizeof(x), 1, bin_out);

    fclose(bin_out);

    return (0);
}

```

Name	Date modified	Type	Size
binaryIO.c	3/24/2023 8:23 AM	C File	1 KB
binaryIO.exe	3/24/2023 8:24 AM	Application	120 KB
binsearch.exe	2/22/2023 10:44 AM	Application	249 KB
circ_calc.c	1/26/2023 11:03 AM	C File	1 KB
circ_calc.exe	1/26/2023 11:03 AM	Application	405 KB
close_enough.c	2/2/2023 2:09 PM	C File	1 KB
close_enough.exe	2/2/2023 2:09 PM	Application	249 KB
complex.c	3/23/2023 2:31 PM	C File	2 KB
complex.exe	3/23/2023 2:31 PM	Application	411 KB
data.bin	3/24/2023 8:24 AM	BIN File	1 KB
data.txt	3/9/2023 9:03 AM	TXT File	1 KB
dice_roll.c	1/26/2023 11:42 AM	C File	1 KB
dice_roll.exe	1/26/2023 11:42 AM	Application	249 KB
enum.c	2/22/2023 8:58 AM	C File	1 KB
	2/22/2023 8:58 AM	Application	249 KB
	3/9/2023 9:15 AM	C File	1 KB
	3/9/2023 9:15 AM	Application	121 KB
	3/15/2023 9:11 AM	C File	1 KB
	3/15/2023 9:11 AM	Application	249 KB



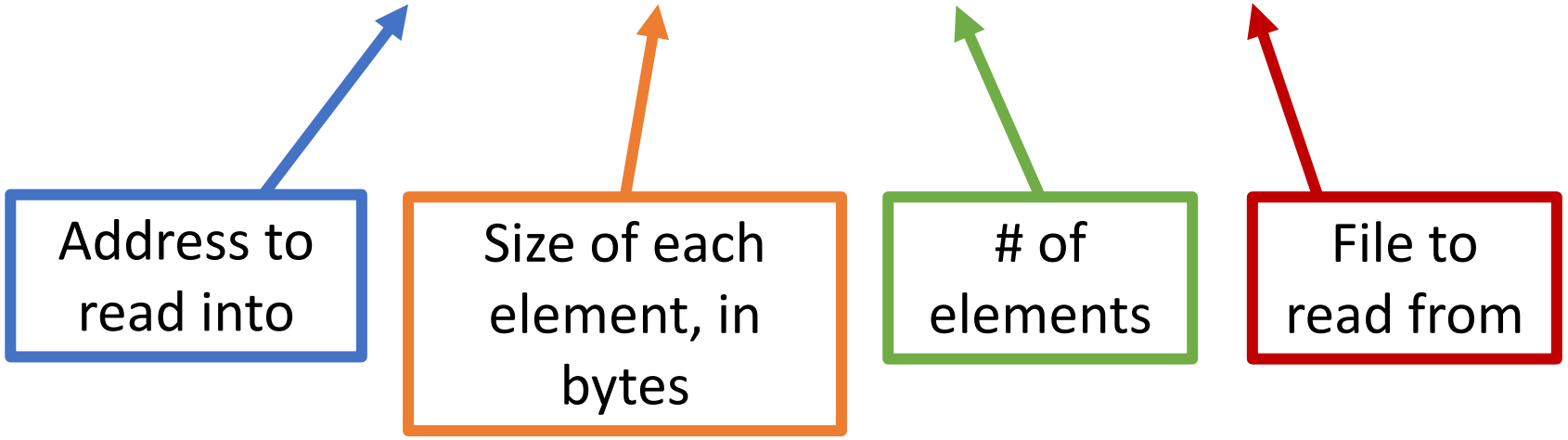
It's not a text file!

- Can't read the contents as ASCII.
- This file contains the two's complement bit pattern for 42

Read Binary, Write Binary

Open it and read as binary:

```
FILE* bin_in;
bin_in = fopen("data.bin", "rb");
int x;
fread(&x, sizeof(x), 1, bin_in);
```



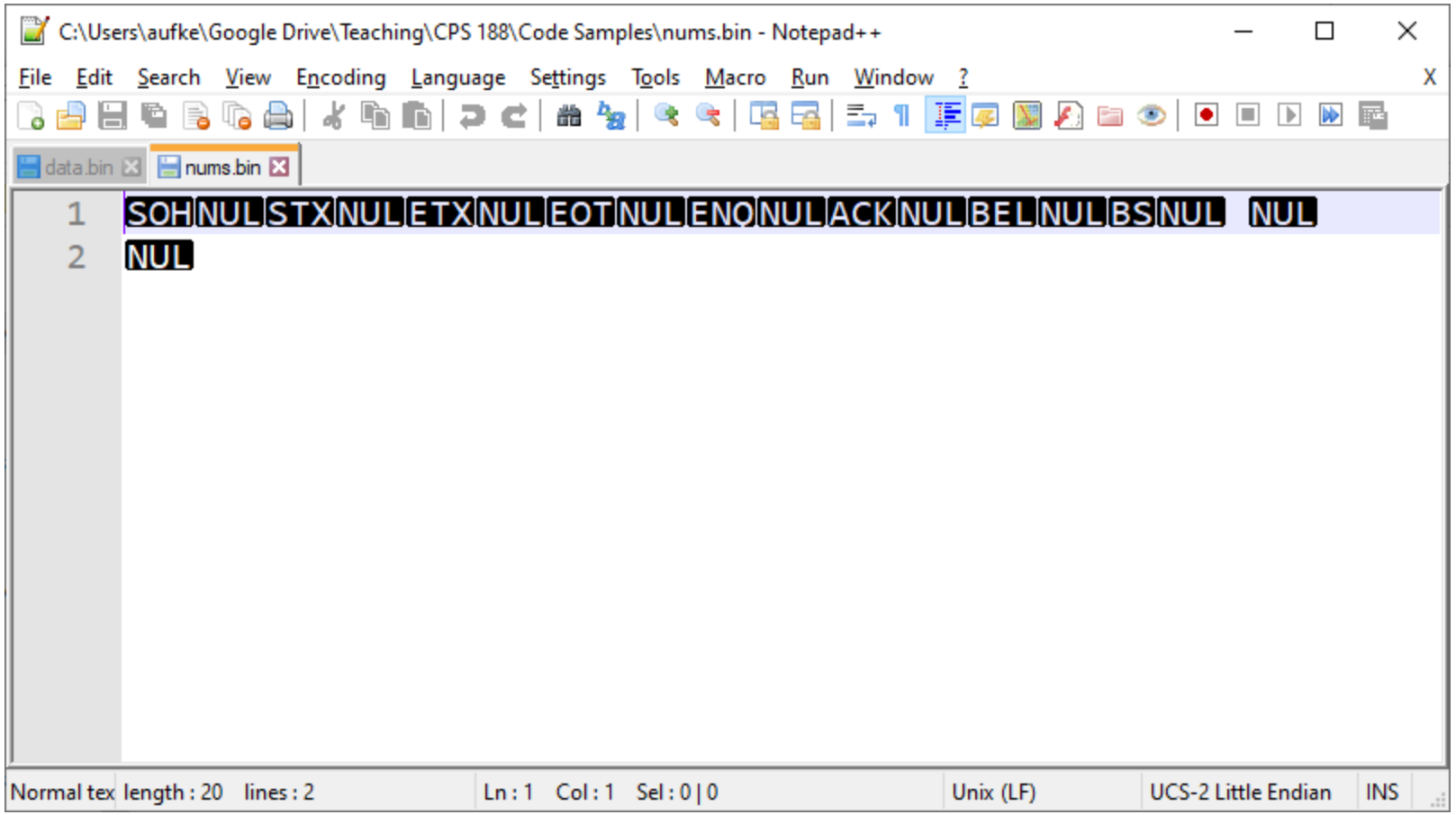
binaryIO.c

```c
#include <stdio.h>

int main (void)
{
    FILE* bin_in = fopen("data.bin", "rb");

    int x;
    fread(&x, sizeof(x), 1, bin_in);

    printf("Read %d\n", x);

    fclose(bin_in);

    return (0);
}
```

A More Powerful Use?

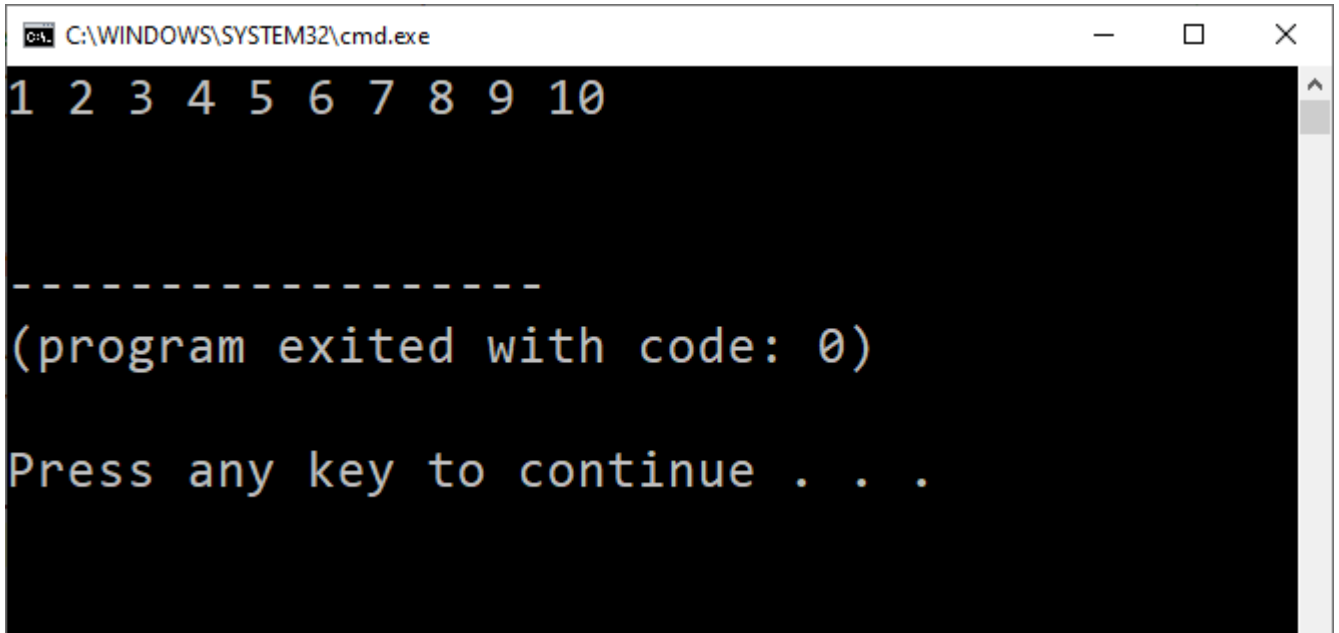
Reading/writing entire arrays in one shot!

```
FILE* bin_out = fopen("nums.bin", "wb");
int arr[] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
fwrite(arr, sizeof(int), 10, bin_out);
fclose(bin_out);
```



binaryIO.c

```c
#include <stdio.h>

int main (void)
{
    FILE* bin_out = fopen("nums.bin", "wb");
    int arr[] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
    fwrite(arr, sizeof(int), 10, bin_out);
    fclose(bin_out);

    FILE* bin_in = fopen("nums.bin", "rb");
    int arr2[10];
    fread(arr2, sizeof(int), 10, bin_in);

    for (int i = 0; i < 10; i++)
        printf("%d ", arr2[i]);
    printf("\n");

    fclose(bin_out);

    return (0);
}
```



Questions?