CSO-1

Type Def and Structs

Daniel G. Graham Ph.D

University of Virginia | ENGINEERING

8. [12 points] Consider the following C code:

```
char first[5] = {'f', 'y', 'i', '!', '\0'};
char *second = strdup("hello");
char *both[2] = {first, second};
```

What is printed for each of the following lines? If the program would crash or seg fault, write **crash**. *Hint:* `printf("%c", x);` *means "print the char stored in variable x."*

A. `printf("%c", (*both)[1]);`

B. `printf("%c", *(both[1]));`

C. `puts(&both[0][2]);`

y, h, i!

CORRECTION ON SIZEOF COMMENT

sizeof() – returns the total number of bytes in the array

```
int x[4] = {1,2,3,4};
int totalNumberOfBytes = sizeof(x); //4*4 = 16


char x[4] = {‘A’,‘B’,‘C’,‘D’};
int totalNumberOfBytes = sizeof(x); //1*4 = 4
```

GENERAL FORMAT OF ARRAY TYPE

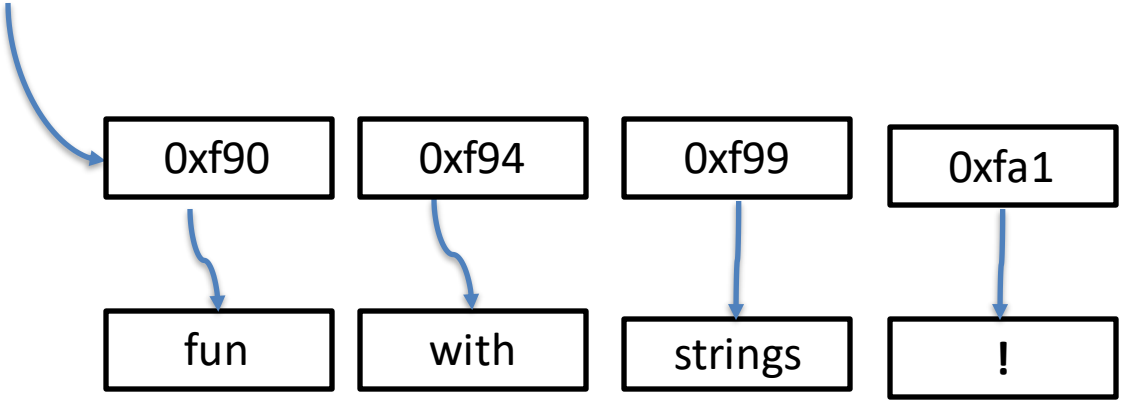
```
int x[4];

____ __[__];
```

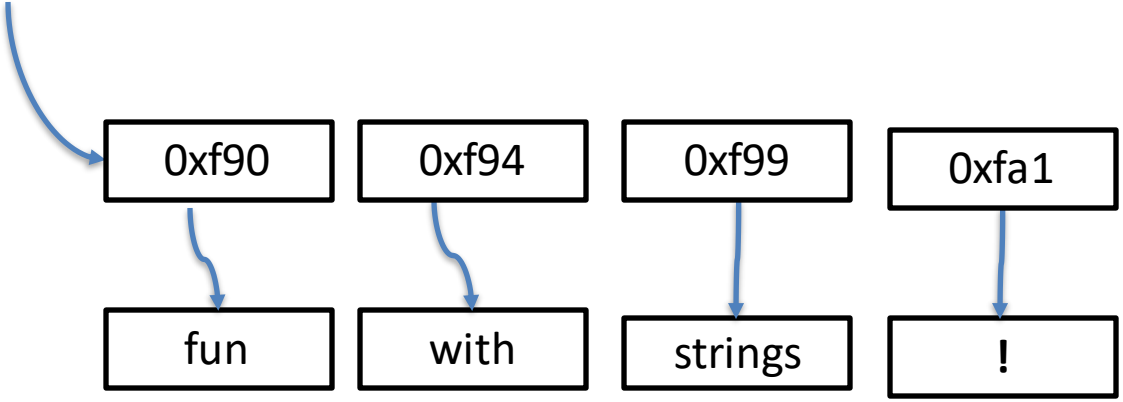
type Variable Name Size

ARRAY OF STRINGS

```
char * strings[4] = {“fun”, “with”, “strings”, “!”};
```



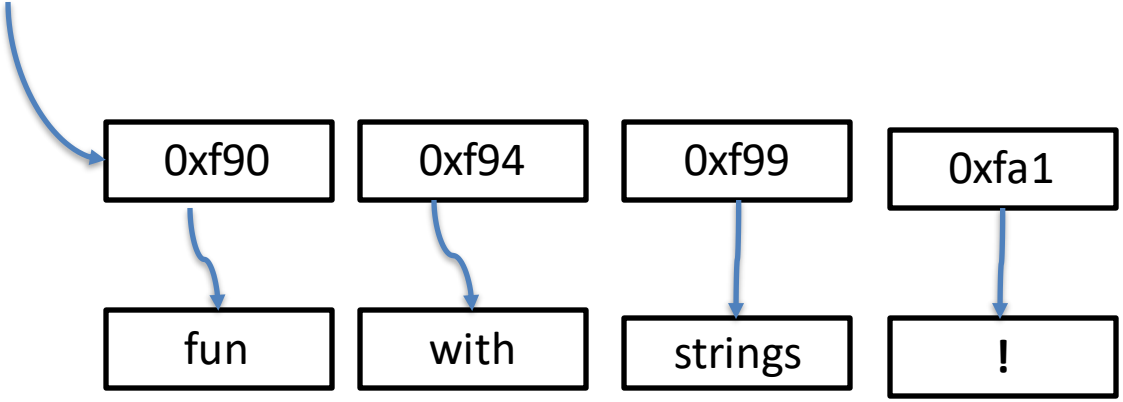
```
char * strings[4] = {“fun”, “with”, “strings”, “!”};
```



Get the third letter of the second word

```
strings[1][2] ⟷ (*(strings + 1))[2] ⟷ *((*(strings + 1)) + 2)
```

```
char * strings[4] = {“fun”, “with”, “strings”, “!”};
```



Get the third letter of the second word

```
char **x = strings;
```

```
(*(x + 1))[2]  ⟷  *((*(x + 1)) + 2)
```

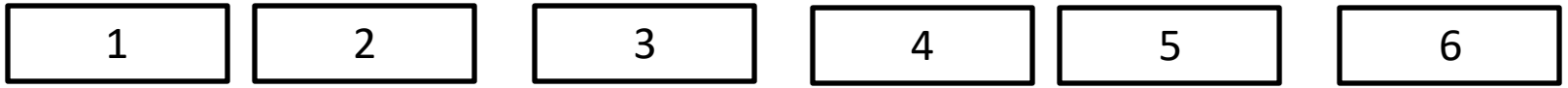
TWO-DIMENSIONAL ARRAYS

```
int matrix[2][3] = { {1, 2, 3}, {4, 5, 6} };
```

	Column 0	Column 1	Column 2
Row 0	1	2	3
Row 1	4	5	6

TWO-DIMENSIONAL ARRAYS

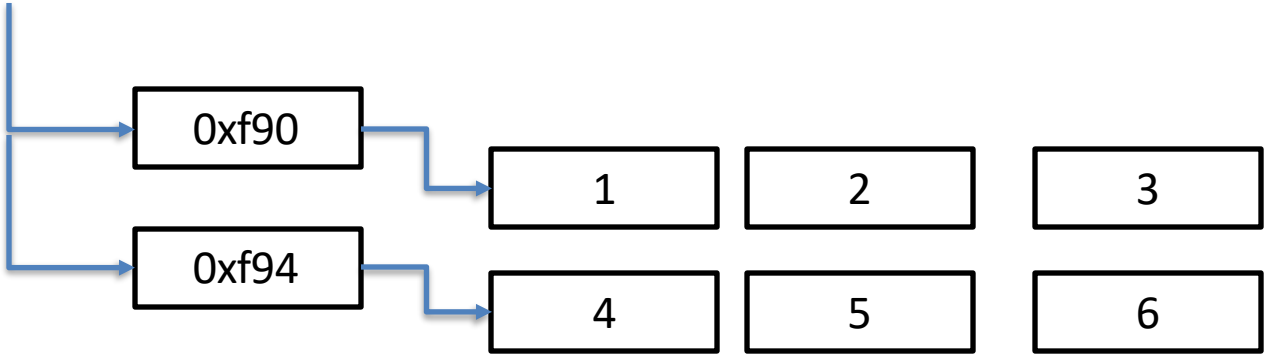
```
int matrix[2][3] = { {1, 2, 3}, {4, 5, 6} };
```



"Row-Major" ordering of all elements in memory

TWO-DIMENSIONAL ARRAYS

```
int count1[3] = { 1, 2, 3};
int count2[3] = { 4, 5, 6 };
int * matrix= { count1, count2 };
```



TYPE DEF

C allows us to give types a new name using the type def keyword.

```
typedef _____ _____;
```

Type info

New name

TYPE DEF

C allows us to give types a new name using the type def keyword.

```
typedef unsigned char byte;
```

Type info

New name

TYPE DEF EXAMPLES

```
typedef int dimension;

dimension height = 3;
dimension width = 4;

dimension area = width * height;

printf(“%d\n”, area);
```

TYPE DEF EXAMPLES

```
typedef char * string;

string name = “Daniel”;
string  AI = “maybe”;

printf(“%s\n”, name);
```

STRUCTS

In C, a struct (short for "structure") is a composite data type that allows you to group together variables of different data types under a single name.

```
struct struct_name {
    data_type member1;
    data_type member2;
    // more members
};
```

STRUCTS

```
struct student{
    int year;
    float grade;
};
```

Tag is optional

```
struct ________{
    _____
    _____
};
```

Don’t forget the semicolon ;

STRUCT USAGE EXAMPLE

```
struct student{
    int year;
    float grade;
};
```

The composite type is: `struct student`

So we declare variables that are of this struct type we need to include both struct and student.

STRUCTS USAGE EXAMPLE

```
struct student{
    int year;
    float grade;
};

struct student daniel;
```

declaring a variable of type struct student.

STRUCTS USAGE EXAMPLE

```
struct student{
    int year;
    float grade;
};

struct student daniel;
daniel.year = 4;
daniel.grade = 77.7;
```

Accessing members of the struct using dot syntax

WHAT IF WE DON'T WANT TO WRITE STRUCT NAME EVERY TIME?

TYPE DEF TO THE RESCUE

C allows us to give types a new name using the type def keyword.

```
typedef _____ _____;
```

Type info

New name

TYPE DEF AND STRUCTS

```
struct student{
    int year;
    float grade;
};

typedef struct student studentType;
```

USING OUR NEW TYPE

```
struct student{
    int year;
    float grade;
};

typedef struct student studentType;
studentType daniel;
studentType jane;
daniel.year = 5;
```

WE CAN COMBINE TYPE DEF AND STRUCT DEFINITION

TYPE DEF

C allows us to give types a new name using the type def keyword.

```
typedef _____ _____;
```

Type info

New name

STRUCTS

```
typedef struct student{
    int year;
    float grade;
} studentType;
```

STRUCTS

Tag is optional

```
typedef struct student{
    int year;
    float grade;
} studentType;
```

```
struct _________{
    ____
    ____
};
```

Since we are not going to need the tag anymore and it is optional, we can choose to omit it.

STRUCTS

```
typedef struct {
    int year;
    float grade;
} studentType;
```

Tag is optional

```
struct _________{
    ____
    ____
};
```

Since we are not going to need the tag anymore and it is optional, we can choose to omit it.

STRUCTS

```
typedef struct {
    char name[50];
    float grade;
} studentType;

studentType daniel;
daniel.grade = 77.7;
strcpy(daniel.name, “Daniel”);
printf(“name %s ”, daniel.name);
Printf(“grade %0.2f \n”, daniel.grade);
```

STRUCTS AND POINTERS

```
typedef struct {
    char name[50];
    float grade;
} studentType;

studentType daniel;
studentType *pointer = &daniel;
```

STRUCTS AND POINTERS

```
typedef struct {
    char name[50];
    float grade;
} studentType;

studentType daniel;
studentType *pointer = &daniel;

(*pointer).grade = 77.7;
float grade = (*pointer).grade;
printf(“grade %0.2f”, grade);
```

SYNTACTIC SUGAR

```
(*pointer).member
```

```
pointer->member
```

STRUCTS AND POINTERS

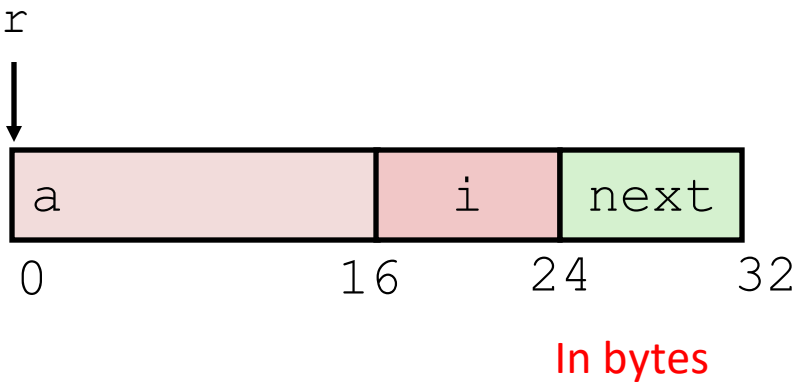
```
typedef struct {
    char name[50];
    float grade;
} studentType;

studentType daniel;
studentType *pointer = &daniel;

pointer->grade = 77.7;
float grade = pointer->grade;
printf("grade %0.2f", grade);
```

STRUCTS AREN'T REFERENCES

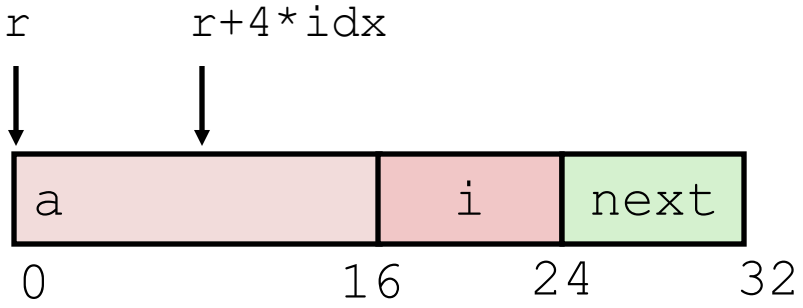
```
struct rec {
    int a[4];
    size_t i;
    struct rec *next;
};
```



Structs are represented as a block of memory big enough to hold all the fields
Fields are ordered according to order they appear in code
Machine level program has no understanding of structures, it just knows where the attributes associated with the struct are located. (The type is lost)

STRUCTS AREN'T REFERENCES

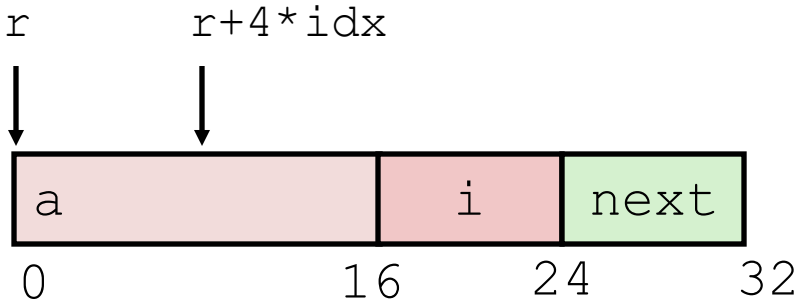
```
struct rec {
    int a[4];
    size_t i;
    struct rec *next;
};
```




```
int *get_ap(struct rec *r, size_t idx)
{
  return &r->a[idx];
}
```

STRUCTS AREN'T REFERENCES

```
struct rec {
    int a[4];
    size_t i;
    struct rec *next;
};
```




```
int *get_ap(struct rec *r, size_t idx)
{
  return &r->a[idx];
}
```

```
# r in %rdi, idx in %rsi
leaq  (%rdi,%rsi,4), %rax
ret
```

UNDEFINED BEHAVIOR

NEXT TIME

1. Discuss Malloc and Free
2. Implement a binary tree in C
3. Do a basic in order traversal