CS 33

Introduction to C
Part 4
Lifetime

```c
int count;

int main() {
    func();
    ...
    func(); // what's printed by func?
    return 0;
}

int func() {
    int a;
    if (count == 0) a = 1;
    count = count + 1;
    printf("%d\n", a);
    return 0;
}
```

undefined.
```c
int main() {
    func(1);  // what's printed by func?
    return 0;
}

int a;
int func(int x) {
    if (x == 1) {
        a = 1;
        func(2);
        printf("%d\n", a);
    } else
        a = 2;
    return 0;
}
```

(continued)
Lifetime (still continued)

```c
int main() {
    func(1); // what's printed by func?
    return 0;
}

int func(int x) {
    int a;
    if (x == 1) {
        a = 1;
        func(2);
        printf("a = %d\n", a);
    } else
        a = 2;
    return 0;
}
```

% ./a.out

1
Lifetime (more ...)

```c
int main() {
    int *a;
    a = func();
    printf("%d\n", *a); // what's printed?
    return 0;
}

int *func() {
    int x;
    x = 1;
    return &x;
}
```

```
% ./a.out
23095689
```

undefined.
Lifetime (and still more ...) 

```c
int main() {
    int *a;
    a = func(1);
    printf("%d\n", *a); // what's printed?
    return 0;
}

int *func(int x) {
    return &x;
}
```

% ./a.out
98378932

undefined.
Rules

• Global variables exist for the duration of program’s lifetime
• Local variables and arguments exist for the duration of the execution of the procedure
  – from call to return
  – each execution of a procedure results in a new instance of its arguments and local variables
Implementation: Stacks

```c
int main() {
    int a;
    func1();
    ...  
}
int func1(int x) {
    int a,b;
    if (x==0) func2(a,2);
    ...
}
int func2(int x, int y) {
    int a,b,c;
    func1();
    ...
}
```
Implementation: Stacks

```c
int main() {
    int a;
    func1(0);
    ...
}

int func1(int x) {
    int a,b;
    if (x==0) func2(a,2);
    ...
}

int func2(int x, int y) {
    int a,b,c;
    func1(1);
    ...
}
```

[Diagram showing stack frames and variables]

CS33 Intro to Computer Systems

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Quiz 1

```c
void proc(int a) {
    int b=1;
    if (a == 1) {
        proc(2);
        printf("%d\n", b);
    } else {
        b = a*(b++)*b;
    }
}

int main() {
    proc(1);
    return 0;
}
```

• What’s printed?
  a) 0
  b) 1
  c) 2
  d) 4
```c
int main() {
    int i, j;
    scanf("%d %d", &i, &j);
}
```

Two parts
- Formatting instructions
  - whitespace in format string matches any amount of white space in input
    » whitespace is space, tab, newline (\n)
- Arguments: must be addresses
  - why?
**#define (again)**

```
#define CtoF(cen) (9.0*cen)/5.0 + 32.0
```

**Simple textual substitution:**

```c
float tempc = 20.0;
float tempf = CtoF(tempc);
// same as tempf = (9.0*tempc)/5.0 + 32.0;
```
Be careful with how arguments are used! Note the use of parentheses in the second version.
Structures

```c
struct ComplexNumber {
    float real;
    float imag;
};

struct ComplexNumber x;
x.real = 1.4;
x.imag = 3.65e-10;
```
Note that when we refer to members of a structure via a pointer, we use the “->” notation rather than the “.” notation.
structs and Functions

```c
struct ComplexNumber ComplexAdd(
    struct ComplexNumber a1,
    struct ComplexNumber a2) {
    struct ComplexNumber result;
    result.real = a1.real + a2.real;
    result.imag = a1.imag + a2.imag;
    return result;
}
```
This doesn’t work, since it returns a pointer to result that would not be in scope once the procedure has returned. Thus the returned pointer would point to an area of memory with undefined contents.
This works fine: the caller provides the location to hold the result.
Using It …

```c
struct ComplexNumber j1 = {3.6, 2.125};
struct ComplexNumber j2 = {4.32, 3.1416};
struct ComplexNumber sum;

ComplexAdd(&j1, &j2, &sum);
```
Arrays of structs

```c
struct ComplexNumber j[10];
j[0].real = 8.127649;
j[0].imag = 1.76e18;
```
Subscripting (i.e., the “[]” operator) has a higher precedence than the “*” operator. Thus `jp` is an array of pointers to `struct ComplexNumber`.
Memory View

jp

j0: 13.6
Quiz 2

```c
struct list_elem {
    int val;
    struct list_elem *next;
} a, b;

int main() {
    a->val = 1;
    a->next = &b;
    b->val = 2;
    printf("%d\n", a->next->val);
    return 0;
}
```

• What happens?
  a) syntax error
  b) seg fault
  c) prints something and terminates
Quiz 3

```c
struct list_elem {
    int val;
    struct list_elem *next;
} a, b;

int main() {
    a.val = 1;
    a.next = &b;
    b.val = 2;
    printf("%d\n", a.next.val);
    return 0;
}
```

• What happens?
  a) syntax error
  b) seg fault
  c) prints something and terminates
Quiz 4

```c
struct list_elem {
    int val;
    struct list_elem *next;
} a, b;

int main() {
    a.val = 1;
    b.val = 2;
    printf("%d\n", a.next->val);
    return 0;
}
```

- What happens?
  a) syntax error
  b) seg fault
  c) prints something and terminates
Quiz 5

```c
struct list_elem {
    int val;
    struct list_elem *next;
} a, b;

int main() {
    a.val = 1;
    a.next = &b;
    b.val = 2;
    printf("%d\n", a.next->val);
    return 0;
}
```

- What happens?
  
a) syntax error
b) seg fault
c) prints something and terminates
for (;;)
    printf("C does not have objects!\n");
This seems pretty weird at first glance. But keep in mind that the name of an array refers to the address its first element, and does not represent the entire array. But the name of a structure refers to the entire structure.

```c
struct Array {
    int A[6];
} S1, S2;

int A1[6], A2[6];

A1 = A2;
    // not legal: arrays don’t know how big they are

S1 = S2;
    // legal: structures do
```
A Bit More Syntax ...

- Constants

  `const double pi =
  3.141592653589793238;

  area = pi*r*r;    /* legal */
  pi = 3.0;        /* illegal */
Note that constant_ptr_to_constant’s value may not be changed, and the value of what it points to may not be changed.
And Still More ...

- Array initialization
  ```
  int SomeMorePrimes[] = {17, 19, 23, 29};
  int MoreWithRoomForGrowth[10] = {31, 37};
  int MagicSquare[][] = {{2, 7, 6},
                        {9, 5, 1},
                        {4, 3, 8}};
  ```