CS 33

Introduction to C
Part 6

Pointers to Structures

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

struct ComplexNumber x, *y;
x.real = 1.4;
x.imag = 3.65e-10;
y = &x;
y->real = 2.6523;
y->imag = 1.428e20;
```

Quiz 1

```
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) prints something and terminates
  b) seg fault
  c) syntax error

Quiz 2

```
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) prints something and terminates
  b) seg fault
  c) syntax error

Quiz 3

```
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) **prints something and terminates**
  b) **seg fault**
  c) **syntax error**

Quiz 4

```
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) prints something and terminates
  b) seg fault
  c) syntax error

Structures vs. Objects

- Are structs objects?

NO!

(What’s an object?)

Structures Containing Arrays

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

int A1[6], A2[6];

A1 = A2;
   // not legal: array variables refer to the
   // addresses of the first elements

S1 = S2;
   // legal: structure variables refer to contents
   // of the entire structure
```

A Bit More Syntax …

- **Constants**

```
const double pi =
 3.14159265358979323 8;
```

```
area = pi*r*r;     /* legal */
pi = 3.0;          /* illegal */
```

More Syntax …

```
const int six = 6;
int nonconstant;
const int *ptr_to_constant;
int *const constant_ptr = &nonconstant;
const int *const constant_ptr_to_constant = &six;

ptr_to_constant = &six;
   // ok
*ptr_to_constant = 7;
   // not ok
*constant_ptr = 7;
   // ok
constant_ptr = &six;
   // not ok
```

And Still More …

- **Array initialization**

```
int FirstSixPrimes[6] = {2, 3, 5, 7, 11, 13};
int SomeMorePrimes[] = {17, 19, 23, 29};
int MoreWithRoomForGrowth[10] = {31, 37};
int MagicSquare[][] = {{2, 7, 6},
                        {9, 5, 1},
                        {4, 3, 8}};
```

Characters

- **ASCII**
  - American Standard Code for Information Interchange
  - works for:
    - » English
    - » Swahili
    - » not much else
  - doesn't work for:
    - » French
    - » Spanish
    - » German
    - » Korean
    - » Arabic
    - » Sanskrit
    - » Chinese
    - » pretty much everything else

Characters

- Unicode
  - support for the rest of world
  - defines a number of encodings
  - most common is UTF-8
    - » variable-length characters
    - » ASCII is a subset and represented in one byte
    - » larger character sets require an additional one to three bytes
  - not covered in CS 33

ASCII Character Set

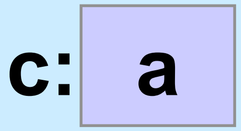
	00	10	20	30	40	50	60	70	80	90	100	110	120
0:	\0	\n			(	2	<	F	P	Z	d	n	x
1:		\v			)	3	=	G	Q	[	e	o	y
2:		\f		sp	*	4	>	H	R	\	f	p	z
3:		\r		!	+	5	?	I	S	]	g	q	{
4:				"	,	6	@	J	T	^	h	r	|
5:				#	-	7	A	K	U	_	i	s	}
6:				$	.	8	B	L	V	`	j	t	~
7:	\a			%	/	9	C	M	W	a	k	u	DEL
8:	\b			&	0	:	D	N	X	b	l	v	
9:	\t			'	1	;	E	O	Y	c	m	w	

chars as Integers

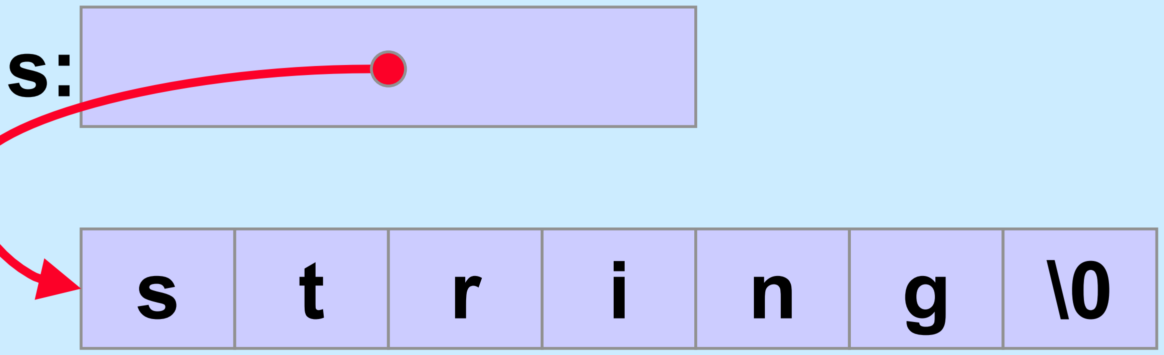
```
char tolower(char c) {
  if (c >= 'A' && c <= 'Z')
      return c + 'a' - 'A';
  else
      return c;
}
```

Character Strings

```
char c = 'a';
```



```
char *s = "string";
```

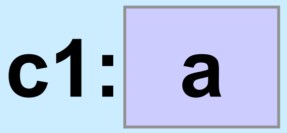


Is there any difference between *c1* and *c2* in the following?

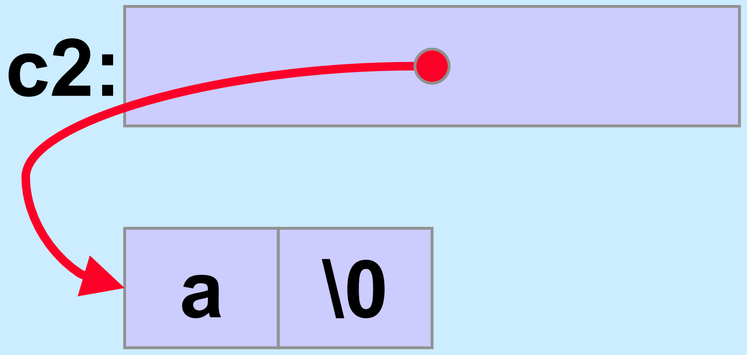
```
char c1 = 'a';
char *c2 = "a";
```

Yes!!

```
char c1 = 'a';
```

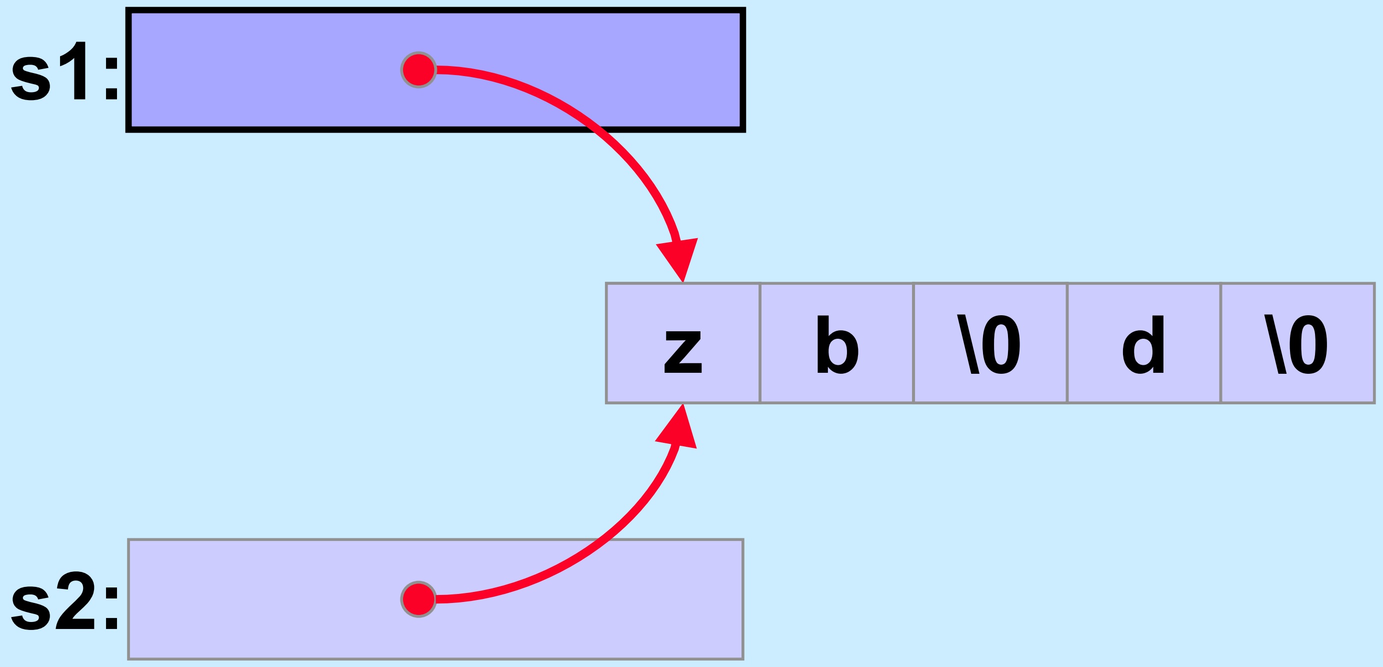


```
char *c2 = "a";
```



What do *s1* and *s2* refer to after the following is executed?

```
char s1[] = "abcd";
char *s2 = s1;
s1[0] = 'z';
s2[2] = '\0';
```


s1:
s2:
z
b
\0
d
\0

Weird …

Suppose we did it this way:

```
char *s1 = "abcd";
char *s2 = s1;
s1[0] = 'z';
s1[2] = '\0';
```

```
% gcc -o char char.c
% ./char
Segmentation fault
```

Copying Strings (1)

```
char s1[] = "abcd";
char s2[5];

s2 = s1;   // does this do anything useful?

// correct code for copying a string
for (i=0; s1[i] != '\0'; i++)
  s2[i] = s1[i];
s2[i] = '\0';

// would it work if s2 were declared:
char *s2;
// ?
```

Copying Strings (2)

```
char s1[] = "abcdefghijklmnopqrstuvwxyz";
char s2[5];

for (i=0; s1[i] != '\0'; i++)
  s2[i] = s1[i];
s2[i] = '\0';
```

Does this work?

```
for (i=0; (i<4) && (s1[i] != '\0'); i++)
  s2[i] = s1[i];
s2[i] = '\0';
```

Works!

String Length

```
char *s1;

s1 = produce_a_string();
// how long is the string?

sizeof(s1); // doesn’t yield the length!!

for (i=0; s1[i] != '\0'; i++)
  ;
// number of characters in s1 is i
// (not including the terminating '\0')
```

Size

```
int main() {
    char s[] = "1234";
    printf("%d\n", sizeof(s));
    proc(s, 5);
    return 0;
}

void proc(char s1[], int len) {
    char s2[12];
    printf("%d\n", sizeof(s1));
    printf("%d\n", sizeof(s2));
}
```

```
$ gcc -o size size.c
$ ./size
5
8
12
$
```

Quiz 5

```
void proc(char s[9]) {
   printf("%d\n", sizeof(s));
}
```

What's printed?

a) 7
b) 8
c) 9
d) 10

Comparing Strings (1)

```
char *s1;
char *s2;

s1 = produce_a_string();
s2 = produce_another_string();
// how can we tell if the strings are the same?

if (s1 == s2) {
  // does this mean the strings are the same?
} else {
  // does this mean the strings are different?
}
```

Comparing Strings (2)

```
int strcmp(char *s1, char *s2) {
  int i;
  for (i=0;
      (s1[i] == s2[i]) && (s1[i] != 0) && (s2[i] != 0);
      i++)
    ; // an empty statement
  if (s1[i] == 0) {
    if (s2[i] == 0) return 0; // strings are identical
    else return -1; // s1 < s2
  } else if (s2[i] == 0) return 1; // s2 < s1
  if (s1[i] < s2[i]) return -1; // s1 < s2
  else return 1;  // s2 < s1;
}
```

The String Library

```
#include <string.h>

char *strcpy(char *dest, char *src);
  // copy src to dest, returns ptr to dest
char *strncpy(char *dest, char *src, int n);
  // copy at most n bytes from src to dest
int strlen(char *s);
  // returns the length of s (not counting the null)
int strcmp(char *s1, char *s2);
  // returns -1, 0, or 1 depending on whether s1 is
  // less than, the same as, or greater than s2
int strncmp(char *s1, char *s2, int n);
  // do the same, but for at most n bytes
```

The String Library (more)

```
size_t strspn(const char *s, const char *accept);
      // return length of initial portion of s
      // consisting entirely of bytes from accept

size_t strcspn(const char *s, const char *reject);
      // return length of initial portion of s
      // consisting entirely of bytes not from
      // reject
```

Quiz 6

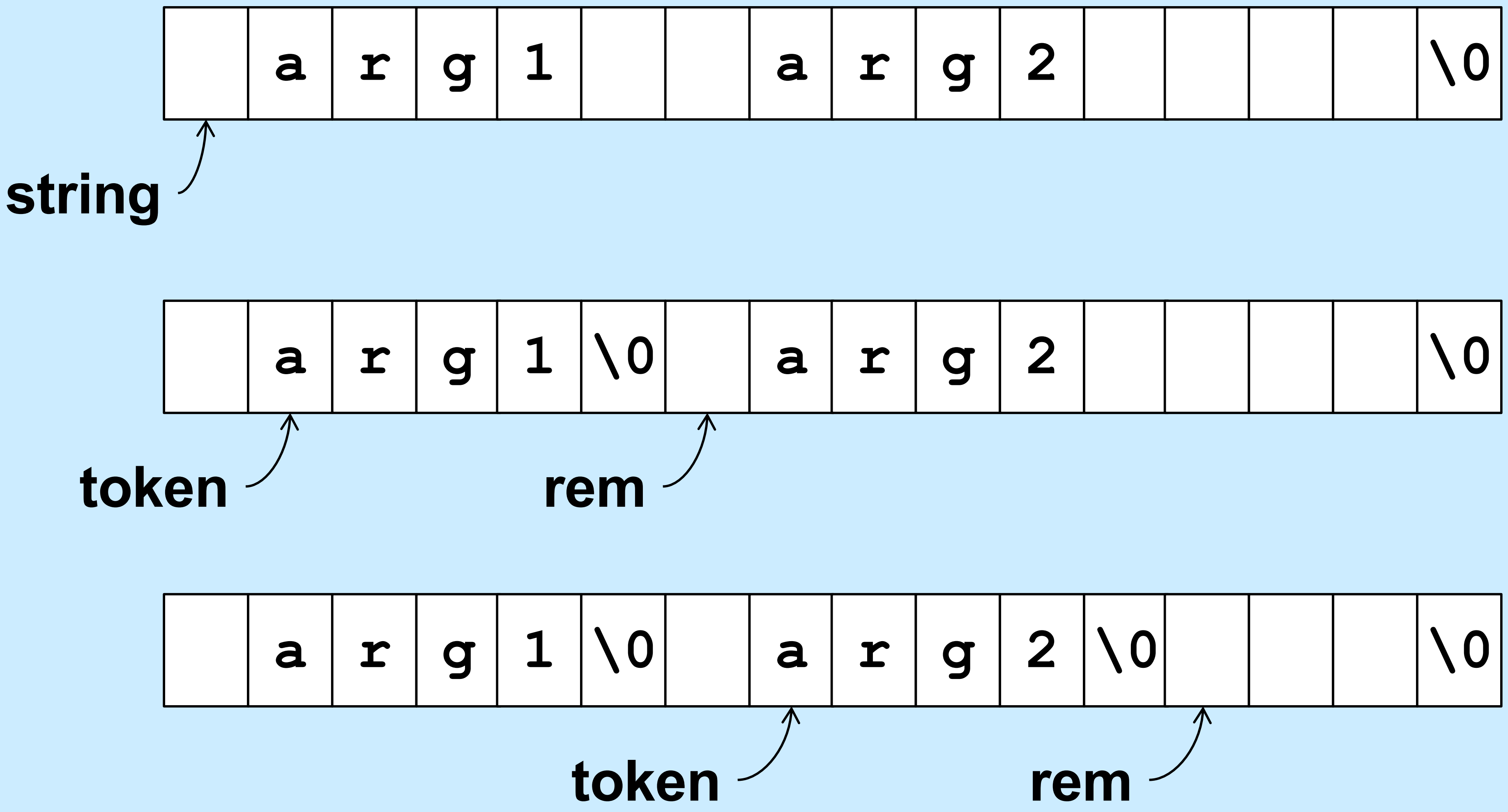
```c
#include <stdio.h>
#include <string.h>

int main() {
  char s1[] = "Hello World!\n";
  char *s2;
  strcpy(s2, s1);
  printf("%s", s2);
  return 0;
}
```

This code:

a) **has syntax problems**
b) **might seg fault**
c) **is a great example of well written C code**

Parsing a String



Designing the Parse Function

- It modifies the string being parsed
  - puts nulls at the end of each token
- Each call returns a pointer to the next token
  - how does it know where it left off the last time?
    - » how is *rem* dealt with?

Design of *strtok*

- **`char`** `*strtok(`**`char`** `*string,`
  `const char` `*sep)`
  - if *string* is non-NULL, *strtok* returns a pointer to the first token in *string* (and keeps track of where the next token would be)
  - if *string* is NULL, *strtok* returns a pointer to the token just after the one returned in the previous call, or NULL if there are no more tokens
  - tokens are separated by any non-empty combination of characters in *sep*

Using *strtok*

```
int main() {
  char line[] = "  arg0   arg1 arg2   arg3   ";
  char *str = line;
  char *token;
  while ((token = strtok(str, " \t\n")) != NULL) {
    printf("%s\n", token);
    str = NULL;
  }
  return 0;
}
```

Output:

```
arg0
arg1
arg2
arg3
```

strtok Code part 1

```
char *strtok(char *string, const char *sep) {
  static char *rem = NULL;
  if (string == NULL) {
    if (rem == NULL) return NULL;
    string = rem;
  }
  int len = strlen(string);
  int slen = strspn(string, sep);
      // initial separators
  if (slen == len) {
    // string is all separators
    rem = NULL;
    return NULL;
  }
```

strtok Code part 2

```
  string = &string[slen]; // skip over separators
  len -= slen;
  int tlen = strcspn(string, sep); // length of first token
  if (tlen < len) {
    // token ends before end of string: terminate it with 0
    string[tlen] = '\0';
    rem = &string[tlen+1];
  } else {
    // there's nothing after this token
    rem = NULL;
  }
  return string;
}
```

Numeric Conversions

```
short a;
int b;
float c;

b = a;    /* always works */
a = b;    /* sometimes works */
c = b;    /* sort of works */
b = c;    /* sometimes works */
```

Implicit Conversions (1)

```
float x, y=2.0;
int i=1, j=2;

x = i/j + y;
  /* what's the value of x? */
```

Implicit Conversions (2)

```
float x, y=2.0;
int i=1, j=2;
float a, b;

a = i;
b = j;
x = a/b + y;
  /* now what's the value of x? */
```