

# Structures

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## Basics of Structures (6.1)

```
struct point {  
    int x;  
    int y;  
};
```

keyword **struct** introduces a structure declaration.

**point**: *structure tag*

**x, y**: *members*

The same member names may occur in different structures.

- Now **struct point** is a valid type.

- Defining **struct** variables:

```
struct point pt;
```

```
struct point
```

```
    maxpt = {320, 200};
```

- A **struct** declaration defines a type.

```
struct { ... } x, y, z;
```

```
or struct point x, y, z;
```

is **syntactically** analogous to

```
int x, y, z;
```

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## Using Structures

- Members are accessed using operator “.”

```
structure-name.member
printf("%d,%d", pt.x, pt.y);
double dist, sqrt(double);
dist = sqrt((double)pt.x * pt.x +
            (double)pt.y * pt.y);
```

- Structures cannot be assigned.

```
struct point pt1, pt2;
pt1.x = 0; pt1.y = 0;
pt2 = pt1; /* WRONG !!! */
```

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## Structure Name Space

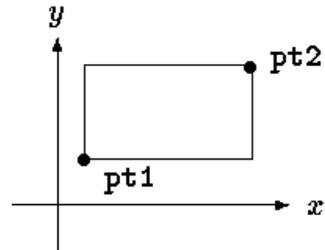
- Structure and members names have their own name space separate from variables and functions.

```
struct point point; /* both are valid */
struct point {
    int x;
    int y;
} x;
```

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## Nested Structures

```
struct rect {
    struct point pt1;
    struct point pt2;
};
struct rect screen;
screen.pt1.x = 1;
screen.pt1.y = 2;
screen.pt2.x = 8;
screen.pt2.y = 7;
```



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## Structures and Functions (6.2)

- Returning a structure from a function.

```
/* makepoint: make a point from x and y components */
struct point makepoint(int x, int y) {
    struct point temp;
    temp.x = x;
    temp.y = y;
    return temp;
}
struct rect screen;
struct point middle;
struct point makepoint(int, int);
screen.pt1 = makepoint(0,0);
screen.pt2 = makepoint(XMAX, YMAX);
middle = makepoint((screen.pt1.x + screen.pt2.x)/2,
    (screen.pt1.y + screen.pt2.y)/2);
```

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## Structures and Functions (cont.)

- Passing structure arguments to functions: structure parameters are passed by values like int, char, float, etc. (a copy of the structure is sent to the function).

```
/* addpoints: add two points */
struct addpoint(struct point p1, struct point p2)
{
    p1.x += p2.x;
    p1.y += p2.y;
    return p1;
}
```

- Note: the components in p1 are incremented rather than using an explicit temporary variable to emphasize that structure parameters are passed by value like any others.

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## Pointers to Structures

- If a large structure is to be passed to a function, it is generally more efficient to pass a pointer than to copy the whole structure.

```
struct point *pp;
struct point origin;
pp = &origin;
printf("origin is (%d,%d)\n", (*pp).x, (*pp).y);
```

- Note: \*pp.x means \*(pp.x), which is illegal (why?)

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## Pointers to Structures: Example

```
/* addpoints: add two points */
struct point addpoint (struct point *p1, struct point *p2)
{
    struct point temp;
    temp.x = (*p1).x + (*p2).x;
    temp.y = (*p1).y + (*p2).y;
    return temp;
}

main() {
    struct point a, b, c;
    /* Input or initialize structures a and b */
    c = addpoint( &a, &b );
}
```

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## Pointers to Structures: Shorthand

- `(*pp).x` can be written as `pp->x`

```
printf("origin is (%d,%d)\n", pp->x, pp->y);
```

```
struct rect r, *rp = &r;
r.pt1.x = 1;
rp->pt1.x = 2;
(r.pt1).x = 3;
(rp->pt1).x = 4;
```

- Note: Both `.` and `->` associate from left to right.

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## Pointers to Structures: More Examples

- The operators `.` and `->` along with `()` and `[]` have the highest precedence and thus bind very tightly.

```
struct {
    int len;
    char *str;
} *p;
*p->str
*p->str++
(*p->str)++
*p++->str
```

```
++p->len ⇔ ++(p->len)
(++p)->len
(p++)->len ⇔ p++->len
```

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## Arrays of Structures (6.3)

```
struct dimension {
    float width;
    float height;
};
struct dimension chairs[2];
struct dimension *tables;
tables = (struct dimension*) malloc
(20 * sizeof(struct dimension));
```

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## Initializing Structures

```
struct dimension sofa = {2.0, 3.0};
```

```
struct dimension chairs[] = {  
    {1.4, 2.0},  
    {0.3, 1.0},  
    {2.3, 2.0} };
```

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## Arrays of Structures: Example

```
struct key {  
    char *word;  
    int count;  
};  
  
struct key keytab[NKEYS];  
struct key *p;  
for (p = keytab;  
     p < keytab + NKEYS; p++)  
    printf("%4d %s\n",  
          p->count, p->word);
```

```
struct key {  
    char *word;  
    int count;  
} keytab[] = {  
    "auto", 0,  
    "break", 0,  
    "case", 0,  
    "char", 0,  
    "const", 0,  
    "continue", 0,  
    "default", 0,  
    /* ... */  
    "unsigned", 0,  
    "void", 0,  
    "volatile", 0,  
    "while", 0  
};
```

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## Pointers to Structures (6.4)

```
struct key keytab[NKEYS];
struct key *p;
for (p = keytab; p < keytab + NKEYS; p++)
    printf("%4d %s\n", p->count, p->word);
```

- `p++` increments `p` by the correct amount (i.e., structure size) to get the next element of the array of structures.

```
struct {
    char c; /* one byte */
    int i; /* four bytes */
};
```

- What is the total structure size?
- Use the `sizeof` operator to get the correct structure size.

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## Self-referential Structures (6.5)

Example: (singly) linked list

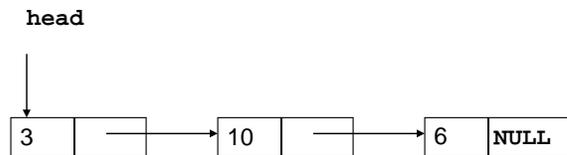
```
struct list {
    int data;
    struct list *next;
};
```



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# Linked List

- Pointer `head` points to the first element
- Last element pointer is `NULL`
- Example (next slide): build a linked list with `data` being non-negative integers, then search for a number.
  - Insertion at the end (rear) of the list.
- We also learn how to dynamically allocate a structure.



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# Linked List Implementation

```
#include <stdio.h>
#include <stdlib.h>
main() {
    struct list {
        int data;
        struct list *next;
    } *head, *p, *last;
    int i;

    /* Create a dummy node, which
       simplifies insertion and deletion */
    head = (struct list *) malloc
        ( sizeof( struct list ) );
    head->data = -1;
    head->next = NULL;
    last = head;
    scanf( "%d", &i ); /* input 1st element */

    while( i >= 0 ) {
        p = (struct list *)
            malloc( sizeof( struct list ) );
        p->data = i;
        p->next = NULL;
        last->next = p;
        last = p;
        scanf( "%d", &i );
    } /* while */

    printf( "Enter the number to search for ";
    scanf( "%d", &i );
    for( p = head; p != NULL; p = p->next )
        if( p->data == i )
            printf( "FOUND %d\n", i );
} /* main */
```

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## typedef (6.7)

- For creating new data type names

```
typedef int Length;  
Length len, maxlen;  
Length *lengths[];
```

```
typedef char *String;  
String p, lineptr[MAXLINES];  
p = (String) malloc(100);  
int strcmp(String, String);
```

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## typedef with struct

- We can define a new type and use it later

```
typedef struct {  
    int x,y;  
    float z;  
} mynewtype;  
mynewtype a, b, c, x;
```

- Now, **mynewtype** is a type in C just like `int` or `float`.

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## Self-referential Structures: More Examples

- Binary trees (6.5)
- Hash tables (6.6)

To be covered later if time permits.

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## Next time ...

- Midterm (Oct. 25)
- Big lab test 1 (Nov. 1)
- Pointers part 2

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