Robotics and
Embedded Systems

A whirlwind tour of C

Echtzeitsysteme WS 2014/2015

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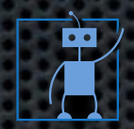
What you should already know



Robotics and
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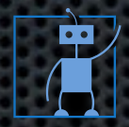
- The basic datatypes (e.g. int, float)
- Basic control flow (e.g. if/else, for, while)
- What functions are
- What classes and objects are
- How to use a compiler

Hello C



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Code

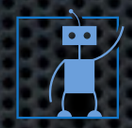
```c
#include <stdio.h>

int main()
{
    printf("Hello World\n");
    return 0;
}
```

Build/Output

```
$ gcc main.c
$ ./a.out
Hello World
$
```

Functions



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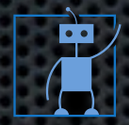
- Reuse and structure code
- Parameters and return value

Functions



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Code

```c
#include <stdio.h>

int fac( int x )
{
    return ( x <= 1 ) ? 1 : x * fac( x - 1 );
}

int main()
{
    printf("%d\n", fac( 5 ) );
    return 0;
}
```

Output

```
$./a.out
120
$
```

Functions

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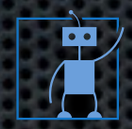
- Return type
  - Function name
    - Argument 0 type
      - Argument 0 name

```
int fac( int x )
{
    return ( x <= 1 ) ? 1 : x * fac( x - 1 );
}
```

arbitrary number of arguments possible

```
type function( type0 arg0, type1 arg1, ..., typeN argN )
{
   ...
}
```

Arrays



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Declaration

Type
Name
Dimension

```
type name[ dimension ];
type name[ dimension1 ][ dimension2 ];
...
```

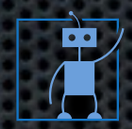
Initialization

```
int array[ 4 ];
array[ 0 ] = 0;
array[ 1 ] = 5;
array[ 2 ] = 8;
array[ 3 ] = 3;
```

```
int array[ 4 ] = { 3, 7, 9, 2 };
```

```
int array[] = { 3, 7, 9, 2 };
```

Arrays



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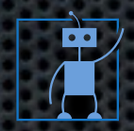
- Special initialization for char arrays / strings
- The following char arrays are equivalent

```
char str[] = "String";
char str2[] = { 'S','t','r','i','n','g','\0' };
```

Pointers



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- A variable name refers to a particular location in memory and stores a value there
- If you refer to the variable by name then
  - the memory address is looked up
  - the value at the address is retrieved or set
- C allows us to perform these steps independently
  - `&x` evaluates to the address of `x` in memory
  - `*( &x )` dereferences the address of `x` and retrieves the value of `x`
  - `*( &x )` is the same thing as `x`

Pointers

Code

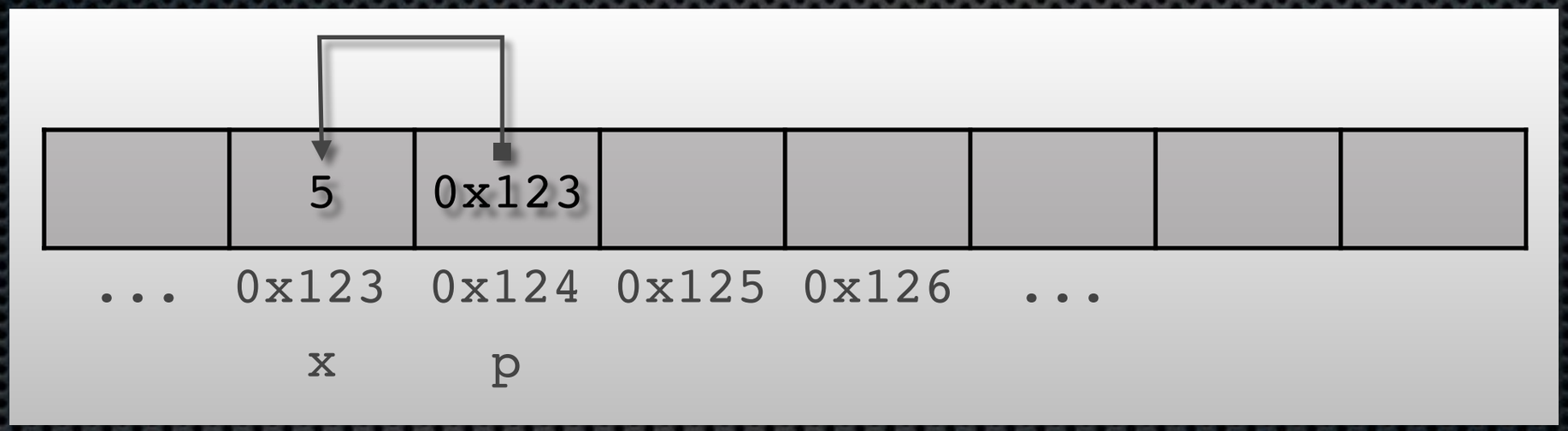
```c
#include <iostream>

int main()
{
    int x;
    int* p = &x;

    x = 10;
    printf("%d\n", *p );

    *p = 5;
    printf("%d\n", x );

    return 0;
}
```

Output

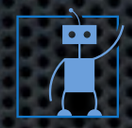
```
$./a.out
10
5
$
```

Pointers

Robotics and Embedded Systems



Pointers



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- Example

```c
#include <stdio.h>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    printf("%d\n", len );
}
```

Pointers

Robotics and Embedded Systems

- Example

```c
#include <stdio.h>

int main()
{
    char* cptr = "bla";
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    while( *cptr != '\0' ) {
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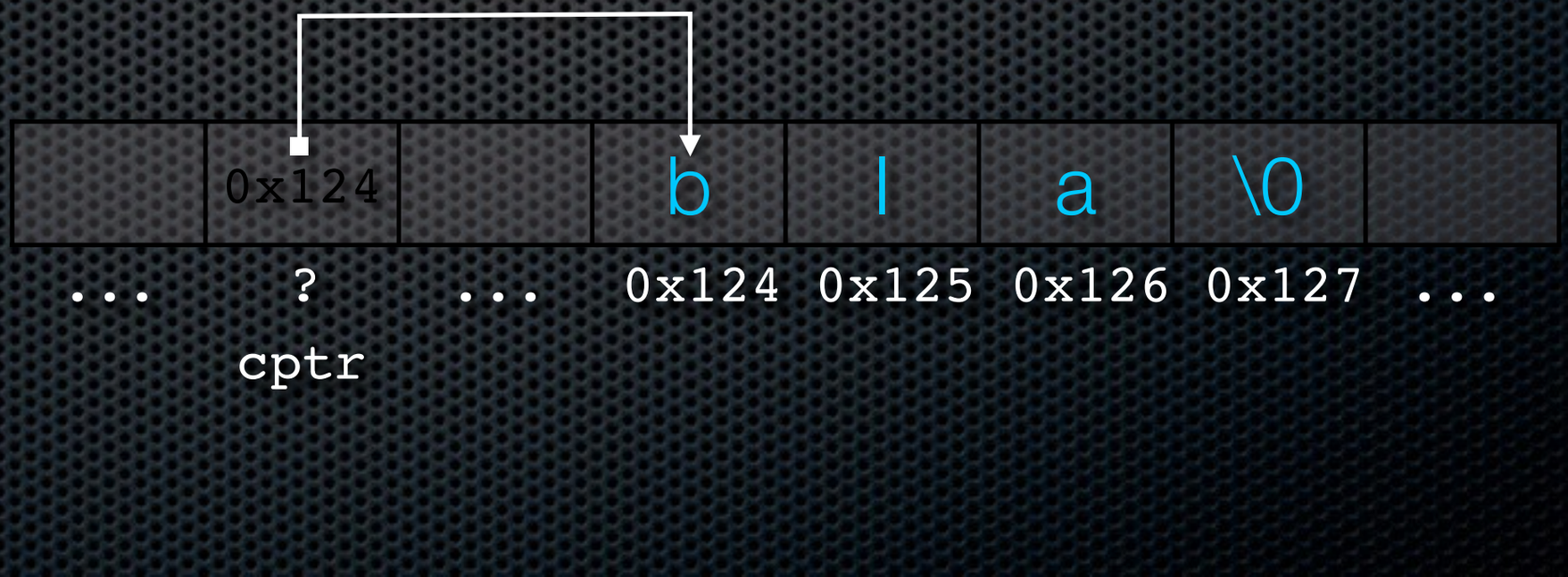
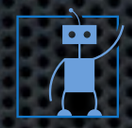
    printf("%d\n", len );
}
```



Pointers



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- Example

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int main()
{
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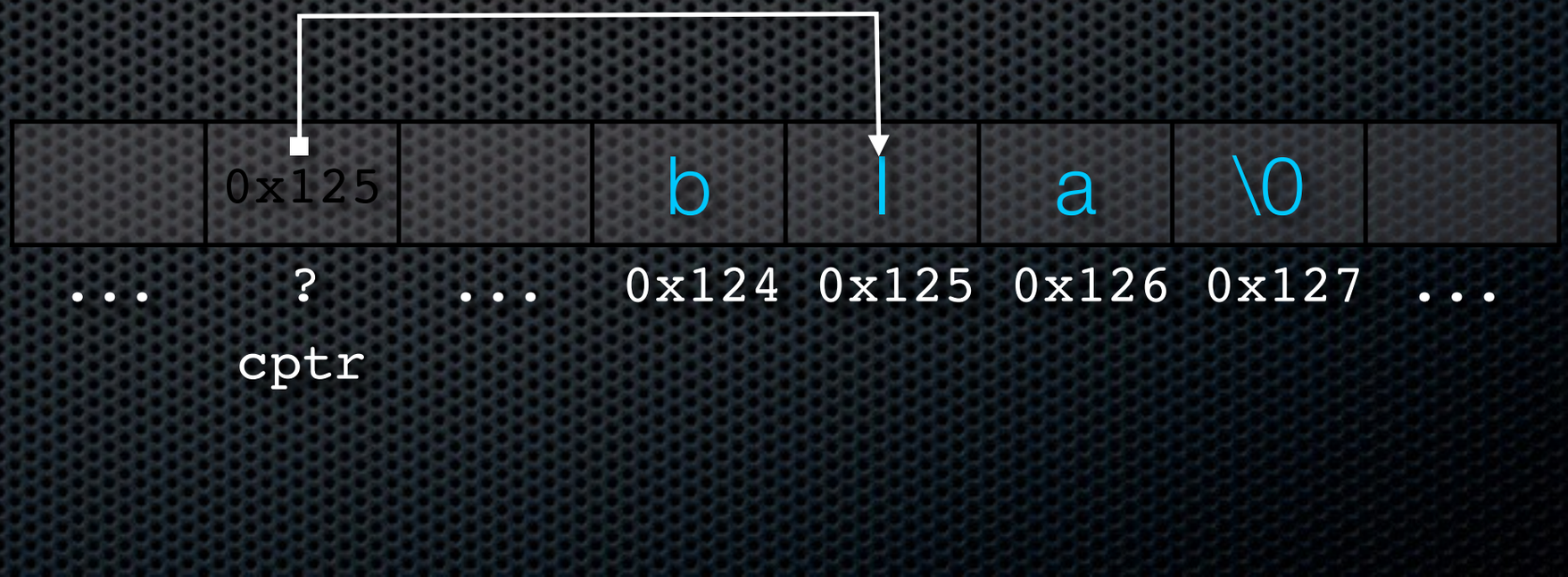
        len++;
        cptr++;
    }
    printf("%d\n", len );
}
```



Pointers

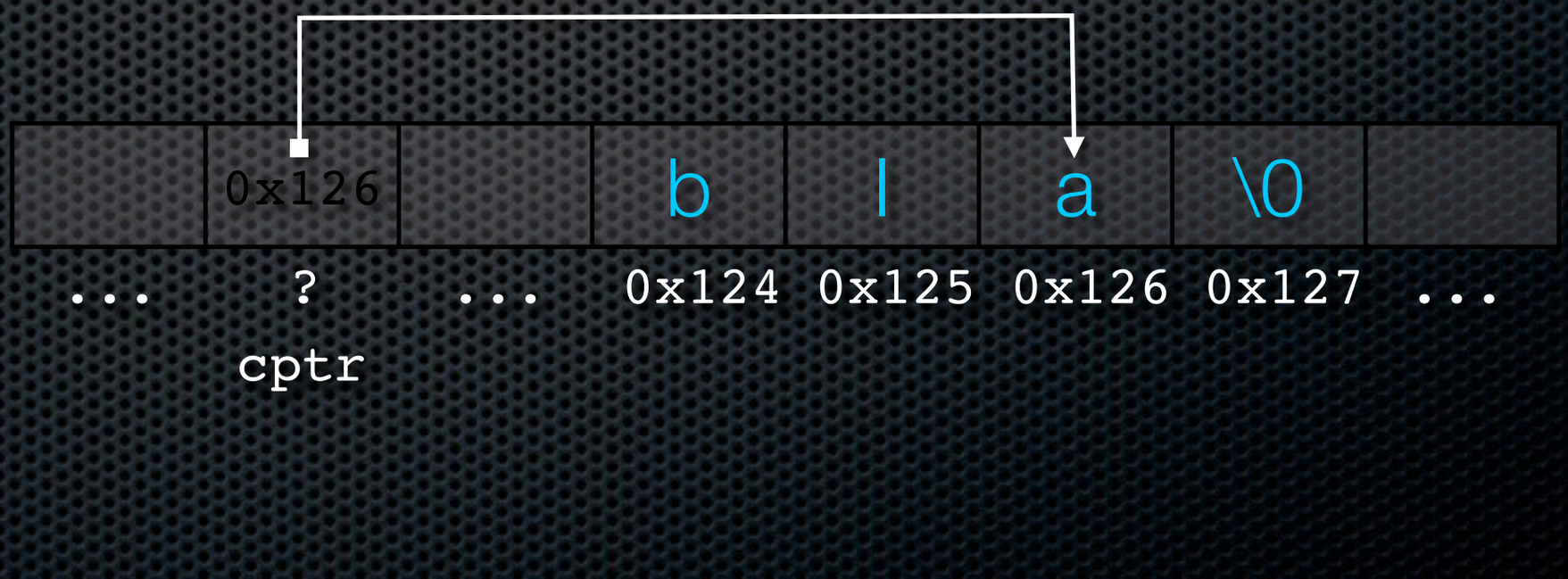
Robotics and Embedded Systems

- Example

```c
#include <stdio.h>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    printf("%d\n", len );
}
```



Pointers

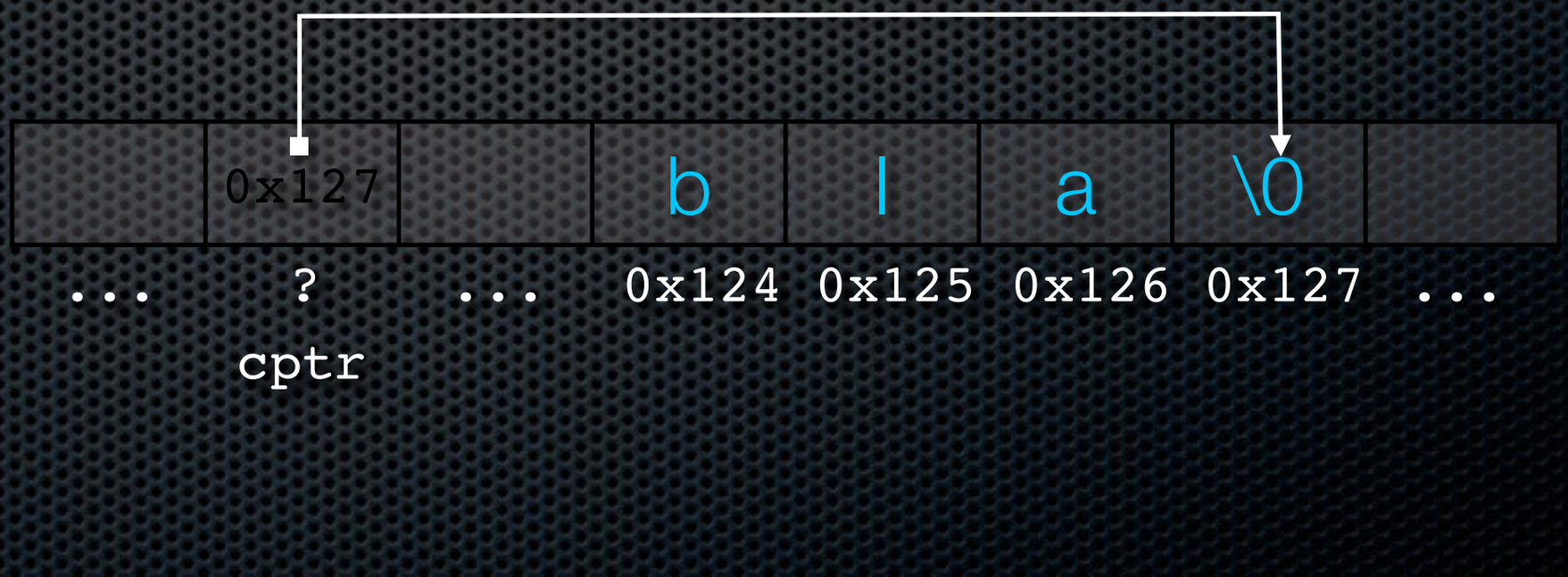
Robotics and Embedded Systems

- Example

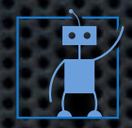
```c
#include <stdio.h>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    printf("%d\n", len );
}
```



Pointers



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- Pointers and arrays

```
int array[ 5 ];
...
         array ≡ &array[ 0 ]
        *array ≡  array[ 0 ]
*( array + 1 ) ≡  array[ 1 ] ≡ 1[ array ]
...
```

- Arithmetic pointer operations modify the address by sizeof(type) bytes

```
#include <stdio.h>

int main()
{
    char*  x = 0x0;
    float* y = 0x0;

    printf("%p\n", ( x + 1 ) );
    printf("%p\n", ( y + 1 ) );
}
```

```
$ ./a.out
0x1
0x4
$
```

Pointers

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```
const int* ptr
```

- Declares a changeable pointer to a constant integer
- value cannot be changed
- pointer can be changed to point to a different constant integer

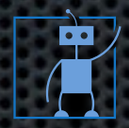
```
int* const ptr
```

- Declares a constant pointer to a changeable integer
- value can be changed
- pointer cannot be changed to point to a different integer

```
const int* const ptr
```

- Neither the value nor the address can be changed

Pointers



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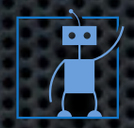
- No guarantees that a pointer points to a valid address

```
...

int* ptr = 0xdeadbeef;
int* ptr = 0x0;

...
```

```
...

int* function()
{
    int x;
    return &x;
}

...

int* p = malloc( sizeof( int ) * 5 );
free( p );

...
```

Memory management



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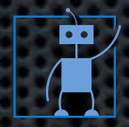
- Dynamic memory allocation possible using malloc/free

```
...
int* x = malloc( sizeof( int ) );
...
int* y = malloc( sizeof( int ) * 10 );
...
float** z;
z = malloc( sizeof( float* ) * 10 );
z[ 0 ] = malloc( sizeof( float ) * 3 );
z[ 1 ] = malloc( sizeof( float ) * 5 );
...
free( x );
free( y );
free( z[ 0 ] );
free( z[ 1 ] );
free( z );
...
```

- If allocated memory is not correctly freed using ‘free’ it is wasted and cannot be reused
- Pointers to freed memory still contain the address

Structures



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- Definition

```
struct name {
    type member1;
     …
    type memberN;
};
```

- Allows the definition of new datatypes
- Structures alllow to collect variables into a new datatype
- Essential for structuring C code
- Enhanced reusability and readability

Structures

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- Example

```
struct vector2 {
    float x;
    float y;
};

typedef struct {
    float x;
    float y;
    float z;
} vector3;

…
```

```
…

int main()
{
    struct vector2 myvec;
    vector3 myvec3;

    myvec.x = 0.0f;
    myvec.y = 0.0f;

    myvec3.x = 0.0f;
    myvec3.y = 0.0f;
    myvec3.z = 0.0f;
}
```

- Structures are often treated as the data part of objects in C and functions operate on the structs like methods on the members

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Questions?