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ACS126 Computing and Systems Design

Lecture 12. Modular Program Design and Functions

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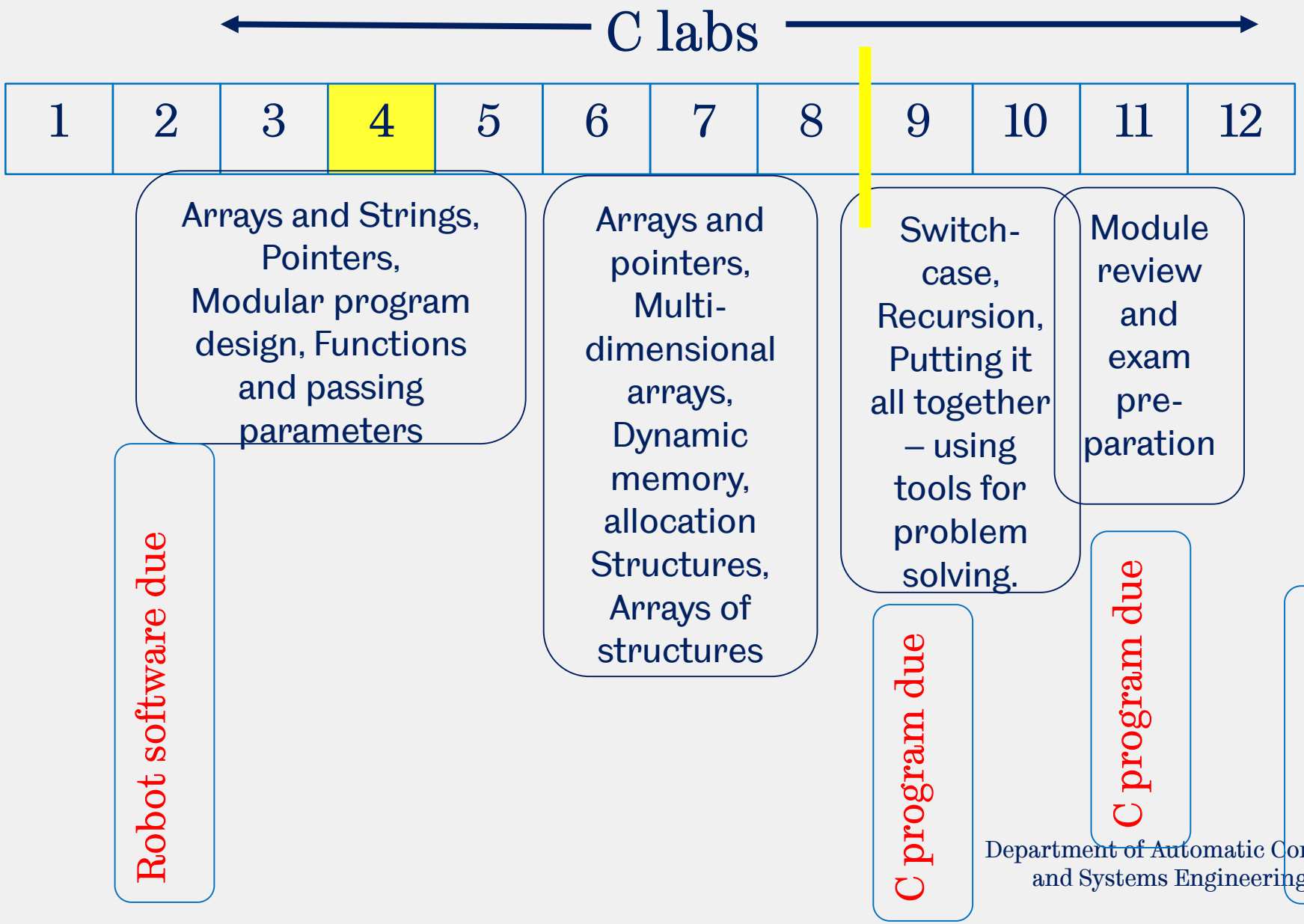
Module roadmap



Learning Outcomes

By the end of this session, students should be able to:

- Solve C software problems systematically and hierarchically, which is reflected in the program design.
- Determine the scope of a variable declared in a C program
- Construct and use C functions using:
  - Pass by value
  - Pass by address

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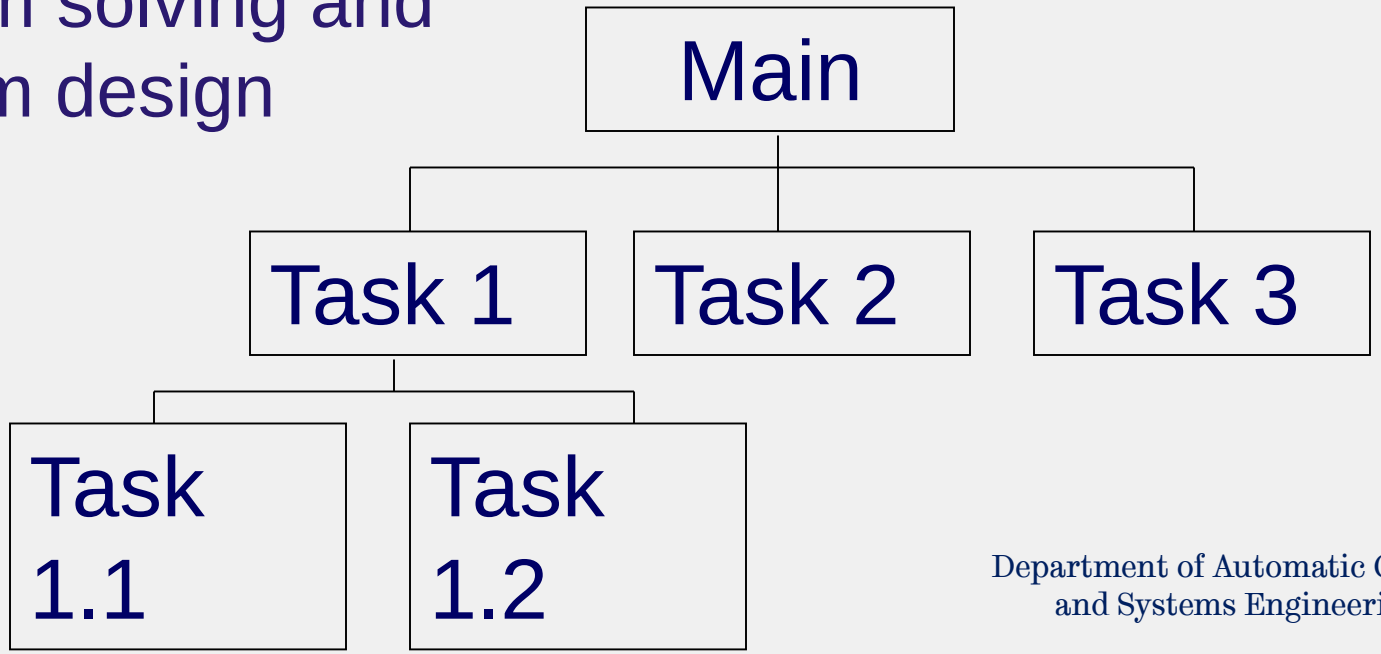
Modularisation

- Subdivision of a large task into manageable chunks.
- The chunks may be simple tasks or complex tasks.
- **Top- down design**: a systematic approach to problem solving and program design



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Advantages in using Modularisation

- Easy to test
- Make it easier for software to be developed by more than one person
- Easy to change
- Readable
  - Reader of main() code can see that all the necessary tasks have been included in the program by looking at the references to the modules

Given a problem, how do we produce a modular solution?

- First determine what are the tasks that must be done.
- Look for verbs/action phrases in a problem description.
- If small tasks are related they can be grouped into a single module.

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Example

- What were the tasks your robot software needed to carry out? What functions did/could you use?

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Modularisation – C functions

- A C function is a module.
- A C function is a block of code with a name. The name allows the function to be used from more than one point in a program, or even from different programs.
- A **block** of code is zero or more programming statements delimited by braces: { …. }
- Note that main() is delimited by braces, and main() is a function. It is the top level function in the top-down design of a program.
- A good function deals with a single processing task.
  - Eg, what would you expect int square(int a) to do?

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FUNCTIONS

Function Prototypes/Declarations

Function Calling

Function Definitions

-> **Passing by value**

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Recap: Function Prototype

- Creates the function:
  - Goes after #include statements, and before `main( )`
  - Gives the definition of 3 aspects of the function:
    1. the type of the return value,
    2. the function name and
    3. the parameter list.

e.g. `int max(int a, int b);`

Always ends with a semi-colon

Type of return value

Function name

Parameter list

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Recap: Function Calling

- The function is called from within main()

e.g.

```
#include <stdio.h>
int max(int a, int b);
main(){
      int int1=2, int2=5, maxValue;
      maxValue= max(int1, int2);
…
}
```

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Recap: Function Definition

- Creating a function- the function body.
- The function body is a block of program code which performs some task(s).
- The function body is headed by a line containing the function return value, name and parameter list.
- The function body header looks like the function prototype, except the function prototype concludes with a ";", and the function body header does not. The program statements that follow the function body header are delimited by { } (just as in main).
- The function body **cannot** go within the { } of main.

```
#include <stdio.h>
int max(int a, int b);
main(){
      int int1=2, int2=5, maxValue;
      maxValue= max(int1, int2);
      printf("Max value is %d.",maxValue);
} //end main
int max(int a, int b){
      if(a>b)
            return a;
      else
            return b;
}
```

Function Prototype

Function Call

Function Definition

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SCOPE OF VARIABLES

Local variables versus Global variables

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Variables

- Scope of variables
  - Global: variable defined throughout entire program
    - Declared before main().
  - Local: variable defined in a limited section of the program
    - Declared in main(), and in any other functions.
- Within main or a function, a variable can be given a value via:
  - Parameter list
  - Reading from the keyboard/file/other device
  - Setting values in an assignment statement (eg, a=1)

```
/* program to illustrate scope, written March 2017, TB*/
#include <stdio.h>
void swap(int a, int b);
main()
{ int i=100, j=200;
  printf("before call to swap in main, i is %d, j is
  %d\n",i,j);
  swap(i,j);
  printf("after call to swap in main, i is %d, j is
  %d\n",i,j);
}
/* function void swap(int a, int b) swaps a and b internal to swap */
void swap(int i, int j)
{ int temp;
  temp=i;
  i=j;
  j=temp;
  printf("in swap function, i is %d, j is %d\n",i,j);
}
```

i and j are local to main function

i and j are local to swap function

```
/* program to illustrate global vars and scope, written March 2017, TB */
#include <stdio.h>
int a,b;  /* global vars */
void swap();
main()
{   a=100; b=200;
    printf("before call to swap in main, a is %d, b is
   %d\n",a,b);
    swap();
    printf("after call to swap in main, a is %d, b is
   %d\n",a,b);
}
/* function void swap() swaps a and b, global vars */
void swap()
{    int temp;
     temp=a;
     a=b;
     b=temp;
     printf("in swap function, a is %d, b is %d\n",a,b);
}
```

Alert: Global variables are dangerous. Avoid them!

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USING POINTERS AS PARAMETERS IN FUNCTIONS

Pass by address

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Pass by Value

- The functions we have encountered use **pass by value**.
  - The function makes a local copy of the parameter in memory, and
  - the value of the variable in the calling function remains unchanged.

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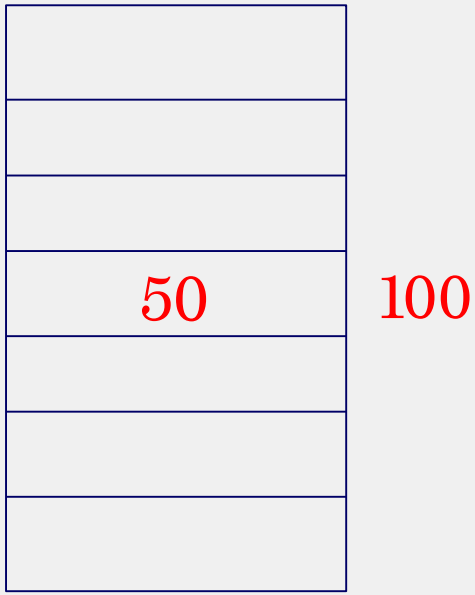
Pass by Value

Memory in main( )

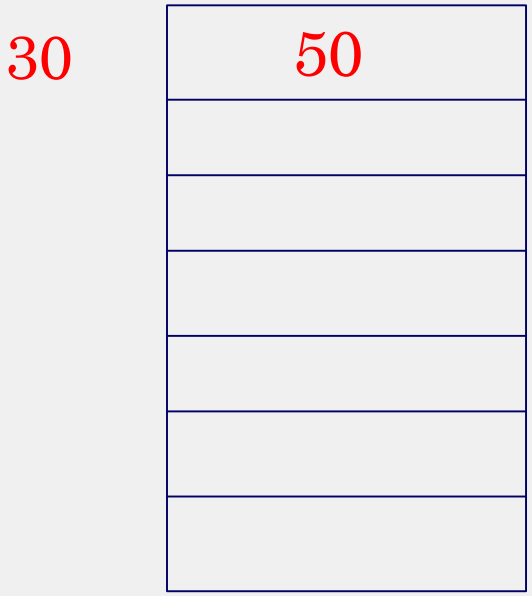


Let's say in main() you have int A=50, stored at memory loc 100.

Function Call

F(A)

Memory in F(int A)



If you then use A in F, you would have access to the value of A only.

Pointers as Parameters

- Functions can also use **pass by address**.
  - To pass a parameter by address, the parameter must be a pointer to a variable.
  - The value of a parameter changed in the function also changes the value of the variable in the calling function.

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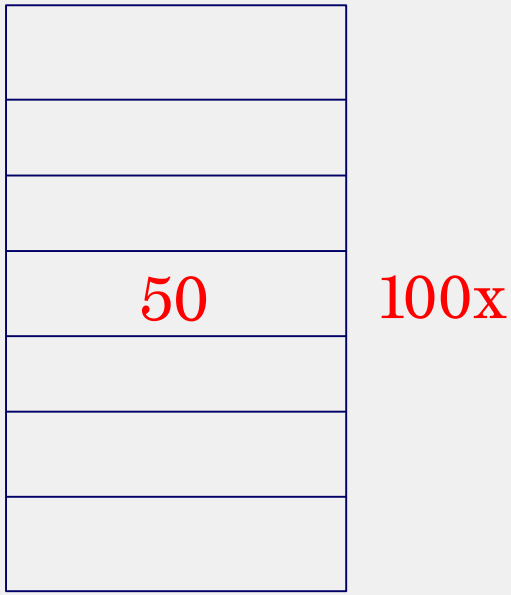
Pass by Address

Memory in main( )



Let's say in main() you have int A=50, stored at memory loc 100.

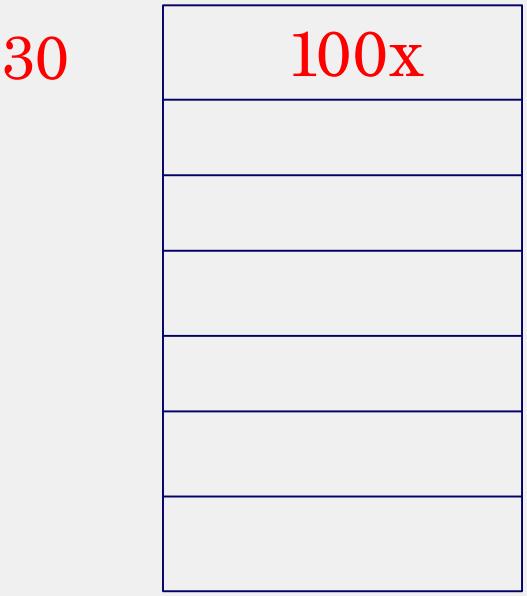
Function Call

F(&A)

Address of A

dereferencing

Memory in F(int *A)



If you then use *A in F, you would have access to the contents of the memory location 100x.

Function Prototype

```
void swap(int *a, int *b);
```

- `int *a, int *b` are pointers to type int
- Function prototype goes before main.

Function Calling

```
swap(&i,&j);
```

- The parameter list consists of the addresses of i and j.
- Function is called within main() or another function.

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Function Definition

```
void swap(int *a, int *b)
{   int temp;
    temp=*a;
    *a=*b;
    *b=temp;
    printf("in swap function, a is
  %d, b is %d\n",*a,*b);
}
```

Same as function prototype

Dereferencing

Example

```
/* program to illustrate pass by address, written March 2017, TB */
#include <stdio.h>
void swap(int *a, int *b);
main()
{   int i=100, j=200;
    printf("before call to swap in main, i is %d, j
       is %d\n",i,j);
    swap(&i,&j);
    printf("after call to swap in main, i is %d, j
       is %d\n",i,j);
}
/* function void swap(int *a, int *b) swaps contents of a and b */
void swap(int *a, int *b)
{   int temp;
    temp=*a;
    *a=*b;
    *b=temp;
    printf("in swap function, a is %d, b is %d\n"
      ,*a,*b);
}
```

```
#include <stdio.h>
void roundFloat(float v, int *r);
main()
{
     float val1=0.3, val2=-24.57;
     int v1,v2;
     roundFloat(val1,&v1);
     roundFloat(val2,&v2);
     printf("%d %d\n",v1,v2);
}
/* function roundFloat
void roundFloat(float value, int *r)
{
   float a,b;
   a=value;
   if(a>=0.0)
        b=value+0.5;
   else
        b=value-0.5;
  *r=b;
 }
```

Test: What will be printed by this program?

Characteristics of a Good Function

- It performs a single task, and it is clear what that task is.
- Only one way in
- Only one way out
- It has a descriptive name.
- The interface (header) to the function is well defined.

Note that the interface to a function using global variables is badly defined.

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Learning Outcomes

By the end of this session, students should be able to:

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- Construct and use C functions using:
  - Pass by value
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