

Complete (but elementary) C programs

- operators and assignment
- sequence, selection and repetition
- functions
- pointers - introduction
- getting input
- arrays and array parameters

Operators

- arithmetic:

operator	integer operands	floating point operands
+ addition	23 + 10 = 33	22.5 + 10.3 = 32.8
- subtraction	23 - 10 = 13	22.5 - 10.3 = 12.2
* multiplication	23 * 10 = 230	22.5 * 10.3 = 231.75
/ division	23 / 10 = 2	22.5 / 10.3 = 2.18446(…)
% remainder	23 % 10 = 3	N/A

- classifications:

- unary operator: one operand, e.g. +(6), -(10.43), ~112
- binary operator: two operands, e.g. 23 + 10, 23 % 10, 17 ^ 114, 0x8 | 0x1
- ternary operator: can you find one?

- relational operators:

operator	description	example
>	greater than	x > 100
>=	greater or equal to	x >= 20
<	less than	x < 100
<=	less or equal to	x <= 20
==	equality	x == 100
!=	non-equality	x != 100

Assignment Statements

- `lvalue = rvalue` e.g. `year = 1900 + 99;`

- value of righthand side is stored in lefthand side
- `rvalue` is a variable, constant or expression
- `lvalue` is a variable

- an assignment statement has a value (that of the righthand side)

```
year2 = year = 1968;
```

- minimal type checking! e.g. with `int year; float length;:`

```
year = 1968.29; /* year becomes 1968 */
```

```
length = 2 / 3; /* length becomes 0.0 */
```

```
length = 2.0 / 3; /*length becomes 0.66... */
```

- `=` is different to the equality operator `==`

```
if (year2 == 1968) ... /*possibly false */
```

```
if (year2 = 2001) ... /*always true */
```

```
if (year2 = 0) ... /* always false */
```

String Assignments and Operations

- string operations require library calls: `month = "Dec" + "ember"` does not work – no in-built string operators!
- we have to use the string library `string.h` (see `man string` on student system)

```
#include <string.h>
...
char month[9];
...
strcpy(month, "Dec");
strcat(month, "ember");
```

- in C, strings are implemented as arrays of `char`

- individual elements of the string variable `month`:

`month[0], month[1], ..., month[8]`

can be accessed the same way as `char` variables, e.g. `month[0] = 'd';`

Precedence, Type Hierarchy and Shorthand Notation

- quiz from lecture C1 !
- logical operators ([King, table 5.3]); bitwise operators ([King, table 20.1-2])
- arithmetic precedence: [King, sect 4.1]
- general operator precedence: [King, table 4.2]
- data type conversion hierarchy: [King, sect 7.5]
- shorthand operators: e.g. `i += 1;`
- increment and decrement operators: e.g. `i++;`

Sequencing and Selection

- statements are separated by semicolons ";" and are executed in the order they appear in the function (program code)
- a statement may be a (or include) call to a function and the statements of that function are then executed first. e.g.

```
i = i+1;  
z = doitI();  
printf( " "%d\n" , z );  
...
```

```
int doit() {  
    int z;  
    ...  
    return z;  
}
```

- selection: alternative instruction (sequences) according to some condition(s)

```
if (i == 1) {  
    /* statement sequence 1 */  
} else if (i > 45 ) {  
    /* statement sequence 2 */  
} else if (i < -42) {  
    /* statement sequence 3 */  
} else {  
    /* statement sequence 4 */  
}
```

Repetition

- three loop constructs in C:

- `while (condition) { ... }`

- `for (start; condition; inc/decrement) { ... }`

- `do { ... } while (condition);`

- use `break` to exit loops in special cases
- use `continue` to 'skip' to the bottom of loop
- never use the `goto` statement!
- e.g. `while` and `for` loops

```
int main(void) {
    int i;
    i = 0;
    while (i < 10) {
        printf("%d\n", i);
        i = i+1;
    }
    return 0;
}
```

```
int main(void) {
    int i;
    for (i = 0; i < 10; i = i+1) {
        printf("%d\n", i);
    }
    return 0;
}
```

Functions

- functions must be declared before they are used
 - e.g. `#include <stdio.h>` for `printf()` definition
 - the definition (i.e. implementation) of the function can come later in the program (or even in a different module)

- a function declaration or 'header' gives its 'type signature'; it consists of:

```
return_type function_name (parameter_list);
```

e.g.:

```
int add(int x, int y);  
int main(void);  
void display(float x, float y);
```

- this gives sufficient information for compiler to tell if function is called properly
 - hence header files are sufficient to use external libraries
- parameters are passed-by-value, so they won't be changed
 - are effectively local variables to the function, except they are initialised when it is called

Example: function.c

```
#include <stdio.h>
int nextYear(int y);
```

```
int main(void) {
    int a, b;
    a = 1981;
    b = nextYear(a);
```

```
    if (b == 1982) {
        printf("1982\n");
    } else {
        printf("Help!\n");
    }
```

```
    printf("Final value of a=%d\n", a);
```

```
    return 0;
```

```
}
```

```
int nextYear(int y) {
    int newYear;

    y = y+1;
    /* change y, but not a! */

    newYear = y;
    return newYear;
}
```

Introduction to Pointers

- a pointer is something which may or may not exist – Anonymous
- variables have 5 attributes: name, type, size, value and *address*
 - size is determined by the type
 - given (in bytes) by the `sizeof()` operator; e.g. `sizeof(i)`, `sizeof(int)`
- a pointer is a variable containing a memory address;
usually this is the address of another (non-pointer) variable
- we can use the memory address to read or modify the value of the variable the pointer refers to. e.g.

```
int y = 1; int *x;  
x = &y; *x = *x + 1;
```

`int *` type for pointer to `int`
`&y` address of `y`
`*x` variable pointed to by `x`

- why are these not valid?

```
&100    &'A'    &(k+2)
```

Getting Input – scanf()

- the `stdio` library provides functions to read values from keyboard and other sources (like files)

```
int scanf(const char *format, ...);
```

- the `format` string contains conversion specifications indicating how many, and what type of values to read
- the subsequent parameters are pointers to the variables in which `scanf()` should store the values
e.g. `scanf("%d", &year);`
- `scanf()` uses whitespace characters (return, tab and space) to decide how to divide the input into separate fields
- e.g. `scanf.c`

```
int a, b;  
scanf("%d_%d", &a, &b);  
printf("sum = %d\n", a+b);
```

Arrays

- a group of n variables of the same type (e.g. a vector), stored sequentially in memory
- a single name applies to the whole array; individual elements accessed using an index in the range $[0, n - 1]$, e.g.

```
int a[3]; /* declares array of length 3 */
int x = 0;
a[0] = 42;
a[1] = 68;
a[2] = a[0] + 2*a[1]; /* this statement is OK */
a[3] = 1;             /* index is too big! what will happen?*/
```

- array names can be used as pointers
 - the name *is* actually a pointer to the first element of the array
 - since array elements are stored contiguously in memory, subsequent elements can be accessed by doing pointer arithmetic, e.g.

```
int a[3];
*a = 42;      /* same as a[0] = 42; */
*(a+1) = 68; /* same as a[1] = 68; */
```

- address of $(a+1) = a + 1 * \text{sizeof}(\text{int})$

Array as Function Parameters: uppercase.c

- while an array parameter (pointer) is passed by value, the memory locations of the array elements are thus effectively passed by reference
- i.e. the function can change the array's elements issue: length of the array?

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

void uppercase(char string[]);

int main(void) {
    char vowels[6];

    strcpy(vowels, "aeiou");
    printf("%s\n", vowels);

    uppercase(vowels);

    printf("%s\n", vowels);

    return 0;
}

// alt.: declare as char *string
void uppercase(char string[]) {
    int i = 0;
    while (string[i] != '\0') {
        string[i] = string[i]
            - 'a' + 'A';
        i++;
    }
}
```

For Next Lecture: Look at string.c

```
#include <stdio.h>
int main() {
    char name[100];
    printf("Enter your name\n");
    scanf("%s", name);
    printf("Your name is %s\n", name);
    return 0;
}
```

- why is there no `&` in this `scanf()`?
- run the program and input both your first and lastname separated by a space.

What is printed out and why?