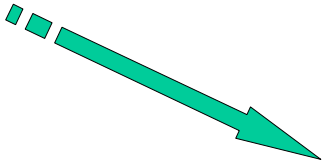
Lecture 12



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Basics of Functions

- We should all be familiar with mathematical functions

  $f(x) = x^2 - 3x + 5$

  – here f denotes the function
  – x is called its argument
  – and the expression $x^2 - 3x + 5$ is an algorithm which describes how to calculate the functions value
- Note that x is merely a placeholder and we could write $f(z) = z^2 - 3z + 5$ *or* $f(p+1) = (p+1)^2 - 3(p+1) + 5$

Basics of Functions

- We can also have functions of several variables

  $g(x,y,z) = x^2 + y^2 + z^2$

  – where there are several variables x,y,z
- Some mathematical functions have special symbols e.g. e^x, *log x, sin x,* $|x|$ *etc* but the principle remains the same
- In C we have a similar idea
- Functions take the form of

```
[return type] [function name] ( [argument list…] )
{
    /* Body of the function where calculations are made*/
    return ; /* functions returns some value*/
}
```

Basics of Functions

- So we can write a function which calculates the square of a number as

```
float square(float x)
{
   return x*x;
}
```

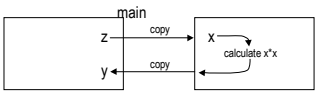
- which is like $f(x) = x^2$
  – this takes a float parameter x (which is the place holder) and returns another float value

Basics of Functions

- The function is "called" as follows

```
float y, z=3.0f;
y=square(z);
```

- Notice that we have used Z as the argument and have assigned the return value to y.
- Diagrammatically:



The argument z is copied to the parameter (placeholder) x

The return value is copied to y

funct1.c

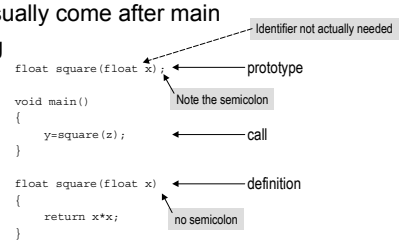
```
/* Example: simple functions */
/* Functions taking one or more arguments and returning a value */
#include <stdio.h>

/* Function prototypes: */
float square(float x);      /* computes x squared */
float cube(float x);        /* computes x cubed */
float power(float x, int n); /* computes x to power n >= 0 */

main()
{
  float X;
  int N;

  printf("Enter a floating point number: ");
  scanf("%f", &X);
  printf("Enter an integer >= 0: ");
  scanf("%i", &N);

  printf("The square of %f is %f\n", X, square(X));

  printf("The cube of %f is %f\n", X, cube(X));

  printf("%f to the power %i is %f\n", X, N, power(X, N));
}

/* Function definitions: */
float cube(float x)  /* computes x cubed */
{ return x * x * x;
}

float square(float x) /* computes x squared */
{ return x * x;
}

float power(float x, int n)  /* computes x to power n >= 0*/
{ /* Note: no check is made for n >= 0! */
  float t = 1;

  while (n > 0)
  {
    t *= x;
    n--;
  }
  return t;
}
```

Function Prototypes

- Recall that we must declare variables (primarily to give them a type) before using them.
- Similarly we must declare functions before using them
- We could do this by putting all functions at the start of the program (before main)
- However this has disadvantages
  - all the details are given before the general outline
  - two function could call each other so it would be impossible to get them in the right order

Function Prototypes

- To avoid this C has function prototypes which go near the start, while the function definitions usually come after main
- eg



Functions with no Arguments

- Sometimes a function has no argument, but returns a value
- To cope with this the void keyword is used
- VOID is used like a data type but means "absence of type" or "no type"

```
int rand(void);
……
int i;
i=rand();
```

- The empty parentheses ( ) are needed!

```
/* Example: simple functions */
/* Function taking no arguments but returning a value */

#include <stdio.h>
#include <stdlib.h> /* for rand */

/* The prototype of rand is int rand(void); */

main()
{
  int n;

  puts("Some random numbers:");
  for (n = 0; n < 10; n++)
    printf("%i ", rand());
  putchar('\n');
}
```

funct2.c

Functions with no Return Value

- Again, void is used to denote a lack of return type for a function.
- The keyword return is used without a following expression or can be omitted if your lazy/sloppy

```
void stars(int n);
……
stars(3);
```

```
/* Example: simple functions */
/* Function taking an argument but returning no value */

#include <stdio.h>

void stars(int n);  /* print a line of n stars */

main()
{
  int n;

  puts("How many stars?");
  scanf("%i", &n);

  stars(n);
}

void stars(int n)  /* print a line of n stars */
{
  while (n-- > 0)
    putchar('*');
  putchar('\n');
  return;
}
```

funct3.c

Functions with no Arguments and no Return Value

```
void print20stars(void);
……
print20stars();
```

```
/* Example: simple functions */
/* Function taking no arguments and returning no value */

#include <stdio.h>

void print20stars(void);  /* print a line of 20 stars */

main()
{
   int k;

  for (k = 0; k < 10; k++)
     print20stars();
}


void print20stars(void)  /* print a line of 20 stars */
{
  puts("********************");
  return;
}
```

funct4.c

Multiple Return Statements

- It is sometimes convenient to have multiple returns
  - e.g. in an if…else or switch statement

```
/* Example: simple functions */
/* Function with multiple return statements */

#include <stdio.h>

int pins(int tn);  /* IC pins lookup */

main()
{
  int ic, p;

  printf("Enter an IC type number: ");
  scanf("%i", &ic);

  p = pins(ic);

  if (!p)
    printf("IC type %i is not recognised.\n", ic);
  else
    printf("IC type %i has %i pins.\n", ic, p);
}
```

```
int pins(int tn)  /* IC pins lookup */
{
  /* Returns the number of pins for an IC of type
number tn. If the type is not recognised, returns
zero. */

  switch (tn)
  {
    case 555: case 741: case 748:
      return 8;
    case 556: case 7400: case 7414:
      return 14;
    case 7448: case 7485:
      return 16;
    case 6502: case 6800: case 8085: case 8088:
      return 40;
    default:
      return 0; /* easily tested */
  }
}
```

funct5.c

Functions Can Call Functions

- Functions need not be called directly from main
- Functions can be called from anywhere, even each other
  - This allows us to break up a job into manageable parts

```
          *
         ***
        *****
       *******
      *********
     ***********
    *************
   ***************
  *****************
          *
          *
       *******
        *****
         ***

  Merry Christmas!
```

xmascard.c

```
/* Example: draws a Christmas card */
/* Function calling another function */

#include <stdio.h>

void draw_tree(void);          /* draws a tree */
void starline(int sp, int st); /* prints sp spaces then st stars */

main()
{
  draw_tree();
  puts("* Merry Christmas!");
}

void draw_tree(void)  /* draws a tree */
{
  int i;

  for (i = 1; i < 19; i += 2)
     starline(9 - i/2, i);
  for (i = 1; i < 3; i++)
     starline(9, 1);
  for (i = 7; i > 1; i -= 2)
     starline(9 - i/2, i);
  putchar('\n');
  return;
}

void starline(int sp, int st)  /* prints sp spaces then st stars */
{
  while (sp-- > 0)
     putchar(' ');
  while (st-- > 0)
     putchar('*');
  putchar('\n');
  return;
}
```

Function Libraries

- Its very useful to have libraries of common functions.
  eg <stdio.h> functions which weve used extensively
- The headerfile (*.h) contains the prototypes
  - stdio.h standard input and output functions
  - string.h string manipulation functions
  - math.h common mathematical functions

math.c

```
/* Example - mathematical functions in the <math.h> library */
/* At the Unix prompt, enter 'man math' for details */

#include <stdio.h>
#include <math.h>  /* contains function prototypes etc. */

main()
{
  printf("fabs(-2.6) = %f\n", fabs(-2.6));   /* absolute value */
  printf("ceil(7.5) = %f\n", ceil(7.5));     /* round up */
  printf("floor(7.5) = %f\n\n", floor(7.5)); /* round down */

  printf("HUGE_VAL = %lf\n\n", HUGE_VAL);    /* "infinity" */
  printf("sqrt(0.5) = %f\n", sqrt(0.5));     /* square root */
  printf("fmod(2.7, 0.5) = %f\n\n", fmod(2.7, 0.5)); /* remainder */

  printf("sin(0.5) = %f\n", sin(0.5));   /* sine */
  printf("cos(0.5) = %f\n", cos(0.5));   /* cosine */
  printf("tan(0.5) = %f\n\n", tan(0.5)); /* tangent */

  printf("acos(0.5) = %f\n", acos(0.5));     /* arccosine */
  printf("asin(0.5) = %f\n", asin(0.5));     /* arcsine */
  printf("atan(0.5) = %f\n", atan(0.5));     /* arctangent */
  printf("atan2(1, 2) = %f\n\n", atan2(1, 2)); /* arctangent */

  printf("exp(0.5) = %f\n", exp(0.5));   /* exponential */
  printf("sinh(0.5) = %f\n", sinh(0.5)); /* hyperbolic sine */
  printf("cosh(0.5) = %f\n", cosh(0.5)); /* hyperbolic cosine */
  printf("tanh(0.5) = %f\n\n", tanh(0.5)); /* hyperbolic tangent */

  printf("log(0.5) = %f\n", log(0.5));     /* natural logarithm */
  printf("log10(0.5) = %f\n\n", log10(0.5)); /* base 10 logarithm */

  printf("pow(0.5, 2.4) = %f\n\n", pow(0.5, 2.4)); /* power */
}
```

Why doesn't this work

funct6.c

```
#include <stdio.h>

void square_it(int num);

main()
{
  int x = 6;

  printf("[main] x = %i\n", x);
  square_it(x);
  printf("\n[main] x squared = %i\n", x);

  return;
}


void square_it(int num)
{
  printf("\n[square_it] num = %i\n", num);
  num *= num; /* multiply num by itself */
  printf("\n[square_it] num squared = %i\n", num);

  return;
}
```