# 88 C Programs

by JT Kalnay

**This book is dedicated to Dennis Ritchie and to Steve Jobs.**

**To Dennis for giving us the tools to program.**

**To Steve for giving us a reason to program.**

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# About This Book

This book is not organized in a traditional chapter format.

Instead I have chosen to include example programs that exhaustively illustrate the important points of C in an evolutionary manner. By working through these programs you can teach yourself C. I assume you already know how to program and are familiar with standard algorithms.

The programs that I present are not, by themselves, complete applications. The programs are "single-issue teaching programs". Experienced programmers who are learning a new language have told me time and time again that they mainly want to see the functionality of the new syntactic and semantic elements. The programmers tell me that they will be able to think of the applicability of the feature to their project. When necessary, I provide a sample application to give a feel for how the new element might be employed.

The programs are presented in an order that presents the simplest, most straightforward aspect of a new element first. Subsequent programs present the more subtle or confusing aspects of a new element. This is a proven pedagogical approach for teaching C that I have presented to over 1,000 professionals and college students.

This book assumes that you are already a programmer and are able to learn well on your own.

Good luck in your study of C.

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## Simple.c  Simplest C program possible

```
main ( )
{
}
```

main is a C keyword.

It is the program entry point.

It does not need to be in column one.

main may take arguments.  We will deal with them later.

The empty round brackets ( ) indicate that we aren't going to worry about the argument list at this point.

A C comment is enclosed by /* …….  */

```
main ( )   /* program entry point  */
{          /* start of block, start of scope */
           Block body
           Block blody
           …
           Block body
}          /* end of block  */
```

{ is the start of scope character
} is the end of scope character

{ and } are referred to as “curly brackets” in this text.

See also "simplest C program possible: Part II full ANSI! compatability" on page 20.2

## hello_world.c Simple program with printf output

All C statements end with a semicolon ;

```
main ( )
{
        /* printf is a c subroutine that you get access to through the standard io
        library */
        /* we will cover #include <stdio.h> later */

        /* in its simplest form printf takes a character string to display */
        /* it may also take other arguments, we will examine these
        later */
        /* printf returns a count of the number of characters it
        displayed */
        /* the count can be ignored */
        printf("hello world \n");
}
```

# prog1.c More on Printf

```
/* stdio.h is the standard input library that provides printf, scanf, and other i/o
routines */

/* #include tells the compiler where to look for input/output routines you call */

/* #include < name of .h file >  will add that .h file to your compilation module */

#include <stdio.h>

int main ( )

{

        /* curly brackets mark the beginning and end of the scope of a compound
statement.

            A compound statement may be a function body, the body of a loop, the body
            of a conditional,

            several statements, …   * /

            printf("C Programming\n");

            printf("C Programming\n");

}
```

```
printf("string to display"); /* string to display is inside quotations" */

/* can provide format specifiers that describe HOW to display things (e.g., as integers, as
strings) */

/* if you put in a format specifier you need to provide a variable to satisfy the format specifier
*/

printf("string format specifier", variables to satisfy format specifiers);
```

**progl.c supplemental variable declaration, printf output, return value**

```
/* to compile with ansi compiler with defaults
        acc prog1.c will produce a.out
        if (ompile is successful no "success indicator" is generated
        if errors, compiler messages will be generated
        executable can be run by typing a.out */

/* to compile with ansi compiler and specify executable's
name
        acc -o    progl prog1.c
        will produce progl if (ompile is
        successful */
/* to pass source code through a very picky pre compiler
       alint progr1.c
*/
/* curly brackets mark the beginning and end of the scope of a compound statement.
        A compound statement may be a function body, the body of
        a loop, the body of a conditional, several statements */
 /* c is an expression language
        every statement returns a value,
        which may be discarded or ignored if unneeded */

/* the next program shows that printf returns the number of characters it printed. */
```

C Programming

value of xyz is 14

C Programming

```
#include <stdio.h>
int main()
{
        /* int declares xyz as a variable of type integer */
        int xyz;

        /* xyz gets return value from printf */
        xyz = printf("C Programming\n");

        /* %i format specifier says print out the value of xyz as an integer */
        printf("value of xyz is %i \n",xyz);

        /* we can ignore the return value of printf */
        /* \n is the newline character */
        printf("C Programming\n");
        } /* program exit point */
```

## Compile, link, run sequence

You can compile C modules to produce object files

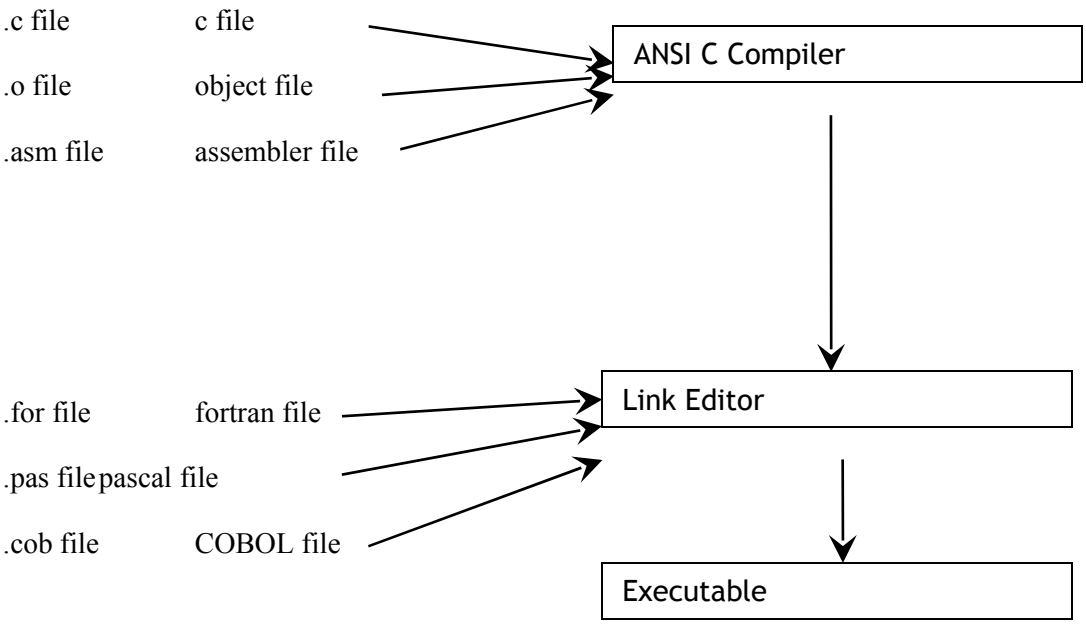
You can assemble Assembler modules to produce object files

You can also compile other (e.g., Fortran, Pascal) programs to produce object files

You can then link all these together

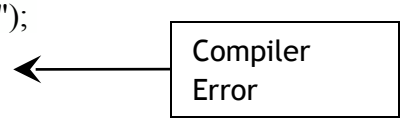
ACC stands for ANSI C compiler

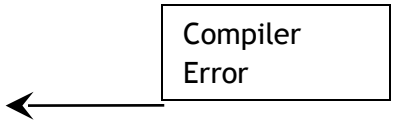
Acc name_of_c_file produces executable a.out



## prog2.c comments case sensitivity

```
#include <stdio.h>

int
ma
in
( )
{

/* comments start with slash asterisk

        can span several lines, and end with asterisk slash */

          int foobar;     /* variable names are case sensitive */

        /* all C statements except comments are case sensitive

              int is OK,  INT is not */

        /* white space is ignored */

           printf("C Programming\n");
           printf("For fun and profit\n");   /* comments can be at the end of a line */


        printf ("Hello /* this is not a comment */ dolly \n");
        print/*comment cannot be nested*/f("H1\n");


           printf("abc\n");                /* comments that span lines
           printf("det\n");                can cause unexpected results… */

        /* the printf("det \n"); statement would not be compiled b/c it is inside a
comment! */

        Printf("value of foobar is %i\n",Foobar);

}
```



## Storage Classes

### Table I

| Type | How Declared | Where Stored | Initial Value | Scope | Lifetime |
|---|---|---|---|---|---|
| Auto | Auto keyword or in function or in block | Stack | None | Function or block | Function or block |
| Static internal | Static keyword in function or block | Heap | Zero if not explicitly initialized | Function or block | Entire life of program |
| External | Outside all functions | Heap | Zero if not explicitly initialized | Entire program | Entire life of program |
| Register | Register keyword | A register, if one is available | None | Same as auto | Same as auto |
| Static external | Static keyword outside all functions | Heap | Zero if not explicitly initialized | Same file after definition | Entire life of program |

C supports different storage classes that you can force by using explicit keywords.

## prog3.c variable declaration and initialization

```
#include <stdio.h>

int main( )
{
        /* declare an integer */
        int x;

       /* do not count on uninitialized variables to have a certain value */

       /* they could be zero and probably will be zero but, could be ??? */
              printf("Unitialized x = %i\n",x);

        x = 1 + 2;

        printf("x with 1 + 2 = %i\n", x);

}
```

Different ways to declare and initialize variables

```
Type_of_variable        name_of_variable
Int                     x;
Float                   y;
Char                    c;
```

```
type_of_ variable   name1, name2, … ;
int                 x,y,z;
float               f1 ,f2;
char                c1,     /* first char * /
                    c2;     /* another char * /
type_of_ variable   name_of_ variable =  initial_value;
int                 a                    =  7;
float               f1                   =  6.7f;
```

type name = initial, name = initial, ... ;

int a = 6, b = 13, c = 12;

## prog4.c printf output of variables

```
#include <stdio.h>

/* this program adds two integer values and */

/* displays the results */

/* it also demonstrates two ways to initialize a variable */

int main( )
{
        /* declare variables */

        int v l; int v2; int vsum;

        /* declare and initialize variable */
        int all_in_one = 5;

        /* initialize values */
        v l = 1;

        v2 = 2;

        /* compute */

        vsum = v l + v2;

        /* print result */
        printf("The sum of %i and %i is %i\n",vI,v2,vsum);

        /* display all in one */
        printf("all_in_one => %i \n",all_in_one);

        /* case sensitivity error, would not compile */

        /* printf("all_in_one => %i \n",ALL_in_one);  */

        /* printf error * /

        print("all_in_one => %i \n",all_in_one);

  }
```

**OPERATORS: RETURN VALUE AND SIDE EFFECTS**

In C, all operators have a return value and some have
"side effects"
A return value isa value given back. For example in the
code:

int a;

8= 3 + 4;

The addition operator (+) returns the result of adding the values 3 and 4.

A side effect is a change in a memory location.
For example:
int a;

a= 7;

The assignment operator (=) changes the memory location we call 'a' to contain the value 7.

The assignment operator also has a return value, namely the new value of a (in our case 7). In this way we can say:

int a,b,c;

a=b=c=7;

7 is assigned into c, c's new value (7) is assigned into b, etc.

NOTE: any statement that has no side effecvt and who's return value is not used adds zero value
to a program.

3 + 4;

the 3 and 4 are added returning 7 which is discarded (like all intermediate results when no longer
needed). Most compilers would flag a line like 3 + 4; with the warning:

"Statement has no effect"

**mathematics operators**

addition +

subtraction -

multiplication *

division /

assignment =

incrementing ++

decrementing --

## ops.c program to demonstrate c operators

```
main ( )
{
        int i.x:
        i = 0;
        x = i++;        /* post increment, return vaule is OLD value, side effect is
increment*/
        printf("i = %i x = %i \n",i ,x);
        i =0;
        x = ++i;        /* pre increment, return vaule is NEW value, side effect is
increment*/
        printf("i = %i x = %i \n", i, x);
        i = 0;
        x = i--;        /* post decrement, return vaule is OLD value, side effect is
decrement*/
        printf("i = %i x = %i \n", i, x);
        i = 0;
        x = --i;        /* pre decrement, return vaule is NEW value, side effect is
decrement */
        printf("i = %i x = %i \n", i, x);
        /* compound assignments: var op= value is the same as var = val op
        value */
```

```
        i = 5;
        i += 2;          /* plus equals, add and assign, same as i = i + 2 */
        printf("i = %i \n",i);
        i = 5;
        i -= 3;          /*  minus equals same as i = i - 3*/
        printf("i = %i \n",i);
        i = 5;
        i *= 4;          /* times equals same as i = i * 4 */
        printf("i = %i \n",i);
        i = 20;
        i /= 2;          /* divides equals same as i = i /2 */
        printf("i = %i \n",i);
        i = 25;
        i %= 7;          /* mod equals same as i =
i % 7*/
        printf("i = %i \n",i);
}
```

**Sample Output From ops.c**

```
i= 1 x = O
i=1  x =  1
i= -1 x= O
i= -1 x= -1
i = 7
i = 2
i = 20
i = 10
i = 4
```

## Exercise 1

```
/* make a file named xone.c */
/* write a C program to compute the following */
/* the result of b squared - 4 times a times c */
/* where a is 5, b is 4, c is 3 */
/* print out the answer * /
/* use variables named a, band c and a variable to hold the result */
/* C does not have a built in square function
        nor does it have a "to the power of" operator*/
```

## Solution for Exercise 1

```
#include <stdio.h>
int main ( )
{
        int a, b, c, result;
        a = 5;
        b = 4;
        c = 3;
        result = ( b * b) – (4 * a * c);
        /* using the ( ) removes doubts about the order of operations... */

        printf("%i squared - ( 4 * %i * %i ) => %i \n", b,a,c,result);

}
```

# Exercise 2

```
/* fix this program by typing it in from scratch
        find the syntax errors and fix them as you go (let the compiler find the errors)
        until it compiles cleanly and runs cleanly and produces the answer 12 */

#include stdio.h
main
      integer i;
        do some math * /
        i=1+2+3
        /* do some more
        math
        i = i + i;

        print(i = %m \n,
        i);
}
/* desired
output */
/*
i = 6              inaccurate
documentation !!
*/
```

```
 #include <stdio.h>
main( )
{
            int i;

            /* do some math * /
            i  = 1 + 2 + 3;

            /* do some more math * /
            i = i + i;

            printf("i = %i \n", i);
  }
  /* desired output * /
  /*
        i = 12
  */
```

# Precompiler:

The precompiler (sometimes called Preprocessor) is the first step in the compilation process. Its purpose is to:

1) remove comments before 'real' compilation

2) perform precompiler statements ( a-k-a Preprocessor directives)

Precompiler statements start with a # as the first non white space character on the line.

We have already seen one:

#include <stdio.h>

This statement asks the precompiler to embed the file stdio.h into our C file at the place where the directive appears.

There are several more that we will examine:

| | |
|---|---|
| # define | perform text subtitution |
| #if <stmt> | conditional include of code |
| #ifdef <stmt> | perform text substitution |
| #ifndef <stmt> | if not defined, include the following code |
| #else | else for any #if |
| #elseif <stmt> | else if for any #if |
| #endif | end of #if block |

## prog4a.c #ifdef precompiler

```
main ( )
{
        #ifdef AAA
        printf("hello from aaa\n");
#endif
#ifdef BBB
        printf("hello from bbb\n");
#else
        printf("What you don't like bbb?\n");
#endif
#ifndef CCC
        printf("defineCCC to stop me before I print again!! \n");
#endif
 }
```

If you compile like this: acc prog4a.c
and run a.out, you see:
What you don't like bbb?
define CCC to stop me before I print again!!!

If you compile like this: acc -DAAA prog4a.c
and run a.out, you see:
hello from aaa
What you don't like bbb?
define CCC to stop me before I print again!!!

If you compile like this: acc -DAAA -DBBB prog4a.c
and run a.out, you will see
hello from aaa
hello from bbb
define CCC to stop me before I print again!!!

If you compile like this: acc -DCCC prog4a.c

and run a.out, you will see

What you don't like bbb?

# prog5.c C basic data types

```
/* acc prog5.c -DCASE1 -o prog5 */
/* acc prog5.c -DCASE2 -o prog5 */
main ( )
{ /* all scalar-variables may be initialized when defined */
        /* program to show declaring variables */
        /* and initializing variables */
#ifdef CASE 1
          char    c       =       'a';
          double d        =       1.23e+45
          float   f       =       123.45;
          int     i       =       321;
  #endif

        /* EXERCISE, change these to valid values */
  #ifdef CASE2
          double d = 'd';
          float f = 2;
          int i  = 1.23;
          char c = d;
  #endif
        /* display character as character */
        printf("c = %c \n",c);
        /* display character as integer */
        printf("c = %d \n\n",c);
        /* display double in scientific */
        printf("d = %e \n",d);
        /* display double in float or scientific */
        /* lets computer decide */
        printf("d = %g \n\n",d);
        /* display float as floating point */
        printf("f = %f\n\n",f);
        /* display integer as base ten integer */
        printf("i = %i \n",i);
        /* display integer as base 16 integer */
```

```
        printf("i = %x \n\n",i);
}
```

# Fundamental Data Types

**To Store A Character**

In C a char is just a subtype (skinny) integer. What we normally think of as a character (displayable) is simply the output to the screen from some display function. Something like 'A' is an integer in C whose value is 65 (ASCII code for A). A statement like: printf("%c", 'A');
asks C to display the character whose code is 65.

**To Store Integers**

char (usualy 1
byte, 8 bits)
short int (at
least 2 bytes)
int (usualy the same size as a
machine word)
long int (usualy at least 4 bytes
perhaps bigger)

**To Store Floating Point Numbers**

float (at least 4 bytes, 7
significant digits)
double (at least 8 bytes, 15 significant digits, may
be larger)
long double (at least 8 bytes, some compilers
support 16 bytes)

**To Store Unsigned Integers, Logical Values and Bit Arrays**

unsigned char
unsigned short int
unsigned int
unsigned long int

**To Store Explicitly Signed Ints**

signed char
signed short int
signed int
signed long int
If the keyword int is removed, say from signed int, the default data type is int so the statements
signed int and signed are syntactally equivalent

**built in operator sizeof(x)**

sizeof( type) returns # of bytes in that type
sizeof(variable) returns number of bytes in that variable

**Relationships Between Sizes of Variables**

1 = sizeof(char) <= sizeof(short) <= sizeof(int) <=
sizeof(long)
sizeof(float) <= sizeof(double) <= sizeof(long
double)
sizeof(char,short,int,long) = sizeof(rsigned) char,short,int,long) = sizeof(Iunsigned)
c,s,i,l)

**NOTE: The following items were intentionally left to the discretion of the compiler writer:**

1) whether the default is signed or unsigned if the programmer does not specify it for (har, short, int or long

2) the exact number of bytes in any data type although minimum ranges have been specified

**pg34.c, illustrates sizeof(var)**

```
NOTE: sizes of different types may vary from system
to system
main ( )
{
        char cl; int il; short sl; unsigned ul;
        long int 11;
        printf("Size of character is %d
        \n",sizeof(cl) );
        printf("Size of short int is %d
        \n",sizeof(sl) );
        printf("Size of unsigned int is %d
        \n",sizeof(ul) );
        printf("Size of int is %d \n",sizeof(il) );
        printf("Size of long int is %d
        \n",sizeof(ll) );
 }
/*
sample
output
*/
/*
Size of
character is
1
Size of short
```

int is 2
Size of
unsigned int
is 4
Size of int is 4
Size of
long int is
4
*/
/* exercise:
modify this program to find out how many bytes a float and a double
consume
*
/

# PORTABILITY CONCERNS

This is not a bad time to say a few introductory words on the issue of portability. One of the strongest arguments for making the change to the C language is that of portability. If a program is coded to the ANSI standard, it *should be* -100% portable if the target platform has an ANSI compliant C compiler available. However, there have been many groups that have learned the hard way that they need to understand, the ANSI standard in order for their programs to work correctly cross-platform.

It is extremely important to note the following in light of our discussion of data types:

a short integer will be at least 2 bytes, but may or may not be 4

an int will typically be the same size as a machine word, but will be at least 2 bytes

a long int will be at least 4 bytes, but could be longer

Any program that needs to be portable (and still function correctly) should be careful to use these data types correctly. Back in '93 a client/server software group learned this the hard way. Their program, which ran fine on an IBM mainframe, hung their PC (DOS machines) even though it had compiled without error or warning. Their program was riddled with counters of type int (keeping track of the number of records read etc.), which would keep track of counts sometimes reaching 1 million or more. Their mainframe compiler had 4 byte ints, their PC compiler had 2 byte ints. (RANGE: 2 bytes = 0 to 65535 4 bytes = 0 to 4,294,967,764)

Suggestion: analyze your data first and ...

-if you mean to store 2 byte quantities use a short

-if you mean to store 4 byte quantities use a long

-if you need a data value the size of a machine word (and adjusts cross-platform)

use an int (handy when writing operating system code or interrupt handlers)

-analysis of the data will also help you decide whether you need specify signed or

unsigned, if there is a need to specify it please do so.

One last word for now ...

Many C compilers come with extra libraries supporting sound, fancy graphics, low-level hard-
ware I/O, etc. Please note that these 'add-in' libraries are generally not ANSI standard and are not supplied with many compilers. (does mouse control mean anything on a 3278 attached to a MVS system) It does you little good to have a program that does fancy screen I/O if it cannot be ported to another platform (unless, of course, it is strictly intended for only one platform)

**Simplest C program possible: Part II**

**full ANSII compatability with no compiler warnings or errors**

```
void main (void): /* prototype for main, usually not required, but
guaranteed
                                to work with all ANSI compilers */
void main( )
{
}
```

OR

```
/* ANSI header stating return type * /
int main(void); /* prototype for main, usually not required, but guaranteed
to work with all ANSI compilers */
int main ( )
{
      return 0;
}
```

# prog6.c mathematics operators, precedence

```
main ( )
{
        /* declare four integers and space for answers */
        int a = 1; int b = 2; int c = 3; int d = 4; int ans;
        /* precedence of - + *
         ( ) parentheses
        -       unary minus     +       unary plus
        ++      increment       --      decrement
        *       multiplication
        /       division
        %       modulo
        +       addition                - subtraction
        ==      equality                = equals     */

        /* print initial values */
        printf("a => %i \t b => %i \t c => %i \t d => %i \n\n",a,b,c,d);

        /* subtraction example */
        ans = a - b;
        printf("a - b = %i \n",ans);

        /* precedence problem, want addition then multiplication */
        ans = a + b * c;
        printf("a + b * c = %i \n",ans);

        /* precedence example */
        ans = ( a + b ) * c;
        printf("( a + b ) * c = %i \n",ans);
}
```

**/* sample output */**

**a => 1 b=> 2 c=>3 d=>4**

**a – b = -1**

**a + b * c = 7**

**( a + b) * c = 9**

## prog7.c mixed mode arithmetic

```
/* program demonstrates mathematics, precedence and the difference between integer
division */
/* how value is stored is determined by destination data type */
/* and floating division *}
main ( )
{
        /* declare and initialize
        integers */ int a = 7; int b
        = 2; int int_ans;
         /* declare and initialize floats */
        float c = 7.0; float d = 2.0; float float ans;
        /* print initial values */
        printf("a => %i \t b => %i \t c => %f\t d =>
%f\n\n",a,b,c,d);
        printf("integer divided by
        integer \n");
        intans = a / b;
        printf("%i / %i = %i \n\n",a,b,int_ans);
        printf("float divided by
        float \n");
        float ans = c / d;
        printf("%f / %f = %f\n\n",c,d,float_ans);
        intans
        = c / b;
        floatan
        s = c /
        b;
        printf(“float divided by integer \n");
        printf(" stored in integer %f / %i = %i
        \n",c,b,int_ans);
        printf(" stored in float %f / %i =
        %f\n\n",c,b,float_ans);
```

```
        printf("integer divided by a
        float \n");
        int_ans = a / d;
        float_ans = a / d;
        printf(" stored in integer %i / %f = %i
        \n",a,d,ineans);
        printf(" stored in float %i / %f =
        %f\n\n",a,d,floaeans);

        printf(("-a = %i \n",-a);
        printf("-c = %f\n",-c);
}
```

## sample output

```
a => 7 b => 2          C => 7.000000 d => 2.000000
integer divided by integer
7/2 = 3              .;
float divided by float
7.000000 / 2.000000 = 3.500000

float divided by integer
stored in integer 7.000000 / 2 = 3

stored in float 7.000000 /2 = 3.500000
integer divided by a float
stored in integer 7 /2.000000 = 3
stored in float 7 /2.000000 = 3.500000

-a =-7
-c = -7.000000
```

## prog8.c the modulus (remainder, residue) operator

```
/* the modulus operator only works on whole numbers*/
main ( )
{
        int guzinta;
        int rem;
        guzinta = 25 /5;
        rem = 25 % 5;
        printf("5 goes into 25 %i times with remainder %i \n",guzinta, rem);
        guzinta = 25 / 7;
        rem = 25 % 7;
        printf("7 goes into 25 %i times with remainder %i \n",guzinta.rem);
  }
```

output you'll see

```
5 goes into 25 5 times with remainder 0
7 goes into 25 3 times with remainder 4
```

**Exercise 3**

```
/* Part 1 */
 /* write a program that evaluates the following expression */
 /* display the result in integer format */
 /*
          ans = 7 times 9 plus 19 divided by 5 modulo 2

          do the multiplication first
                    the division second
                    the modulo third
                    and the addition last
 */
 /* Part 2 */
 /*  write a program that evaluates the following expression */
 /* use exponential formats for the numbers */
 /* display the result in exponential format */
 /*  (.000000097 + 2010 ) / ( 89000 * 23) */
```

**Solution for Exercise 3**

```
main ( )
{
        int ans;
        float a,b,c,d;
        float numerator;
        float denominator;
        float result;

      a = 9.7e-8;
      b = 2.01e3;
      c = 8.9e4;
      d = 23.0;

      ans = ( 7 * 9 ) + ( ( 19/5 ) % 2);
      printf("ans = %i \n",ans );
      numerator = a + b;
      denominator = c * d;
      printf("numerator = %e \n",numerator);
      printf("denominator = %e \n",denominator);
      result = numerator / denominator;
      printf("Result = %e \n",result);
  }
```

# Relational (Comparison) Operators

< less than

> greater than

== equivalent to

<= less than or equivalent to

>= greater than or equivalent to

!= not equivalent to

Relational operators are used in relational expressions. A relational expression is defined as anything that can produce a True or False answer. Falsity is defined as zero. Truth is defined as non-zero. A variable by itself can be a relational expression because its value will be examined to see if it is zero or non zero. A relational expression can exist by itself, it does not have to be examined within the context of a decision.

The relational operators return a 1 if true,
0 if false.

```
/* steve.c August 10, 1993 */
main ( )
{
        int x, y, z;
        y = 2;
        /* y = 3 is a relational expression * /
        /* its truth or falsity is assigned to x */
        x = y == 3; /* assign to x the result of the comparison */
        printf("AAA x = %i y = %i\n",x,y);

        y = 3;
        /* y == 3 is a relational expression * /
        /* its truth or falsity is assigned to x */
        x = y == 3;
        printf("BBB x = %i Y = %i\n",x,y);

        x == y; /* no side effect, return value not used, this does nothing */
        printf("CCC x = %i y = %i\n",x,y);
        x < y;
        printf("DDD x = %i y = %i\n",x,y);
        z = x < y;
        printf("EEE z = %i x = %i Y = %i\n",z,x,y);

/* sample output */
AAA x= O y = 2
BBB x = 1  y  = 3
CCC x = 1 y  = 3
DDD x = 1 y = 3
EEE z = 1 x = 1 Y = 3
```

Run this program through alint and see that it tells you that there are several bugs.

## prog9a.c three types of loops

```
main ( )
{
          int sum;
          int n;
          /* sum and loop counter need to be initialized */
          sum = 0; n = -5;

        /* while (relational expression) */
        /* while loop, check condition at top */
        while ( n <= 5 )
        {
                sum = sum + n;
                n = n + 1;
                printf("n is %i sum is %i \n",n,sum);
        }
        printf("WHILE LOOP:sum is %i \n\n\n",sum);

        /* do loop, check condition at bottom */
        sum = 0; n = -5;
        do
        {
                sum = sum + n;
                n = n + 1;
                printf("n is %i sum is %i \n",n,sum);
        } while ( n, <= 5 );
        printf("DO LOOP:sum is %i \n\n\n",sum);

        /* for loop, C shorthand to get all loop things on one line */
        for ( sum = 0, n = -5; n <= 5; n++ )
        {
                sum = sum + n;
        }
        /* print out the results */
        printf("FOR LOOP:sum is %i \n\n",sum);
}
```

# progl0.c for loop

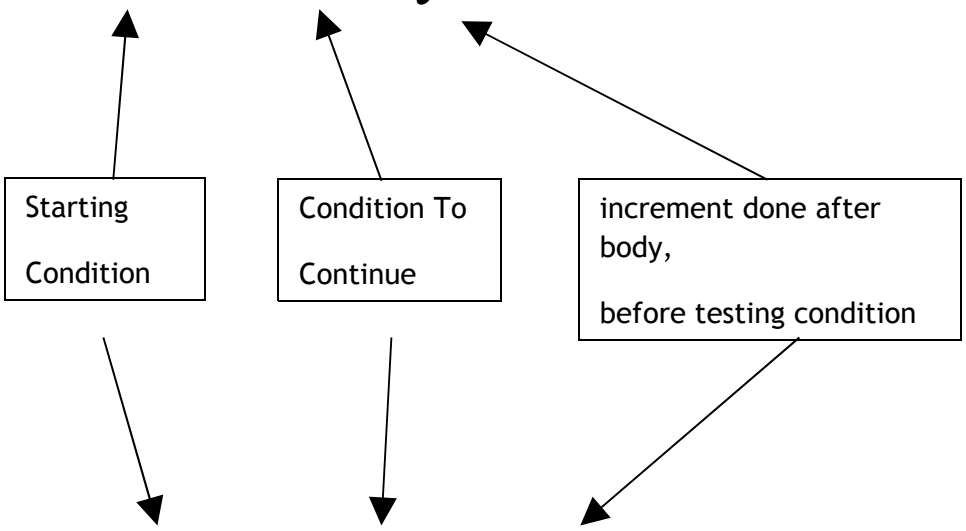
```
/* program to calculate squares
* /
ma
in
( )
{
        int square;
        int n;
        printf("TABLE OF SQUARES NUMBERS \n\n");
        printf("\t n \t n squared\n");
        printf("\t---\t----------\n");
        for ( n = 1; n <= 20;
        n++ )
        {
                square = n * n;
                printf("\t %i \t %i
                \n",n,square);
      }         \t is the tab character
}
```

TABLE OF SQUARES NUMBERS

| n | n squared |
|---|---|
| 1 | 1 |
| 2 | 4 |
| 3 | 9 |
| 4 | 16 |
| 5 | 25 |
| 6 | 36 |
| 7 | 49 |
| 8 | 64 |
| 9 | 81 |
| 10 | 100 |
| 11 | 121 |
| 12 | 144 |
| 13 | 169 |
| 14 | 196 |
| 15 | 225 |
| 16 | 256 |
| 17 | 289 |
| 18 | 324 |
| 19 | 361 |
| 20 | 400 |

# Comparison of Loop Syntax

For  a = 1 to 37 by 2




For ( n = 1; n <= 20; n++)

n is initialized to 1 // n = 1

perform test, // if n <= 20

if true, do body

if false, skip body

after body performed, do increment

//n++

Exercise: Rewrite the previous example (progl0.c) and replace the for loop with

a while loop, and then a do-while loop.

Exercise: Make the previous program do the table of squares from 10 to 50

by 2's. i.e, 10 12 14 16 ...

Exercise: Make the previous program do the table of squares from 33 to -7

by -3's i.e. 33, 30,27,24 ...

## prog11.c for loop scanf input

```
/* program to calculate squares * /
/* introduces scanf for
  user input */
main ( )
{
        int square;
        int cube;
        int n;
        int user number;
        printf("How far do you want to go to? \n");
        scanf("%i",&user_number);
        printf("\nYou entered %i \n\n",user_number);
        printf("TABLE OF SQUARES & CUBES\n\n");
        printf("\t n \t n squared \t n cubed\n");
        printf("\t---\t----------\t ---------\n");
        for (n = 1; n <= user_number; n++)
        {
                square = n * n;
                cube = square * n;
                printf("\t %i \t %i \t\t %i\n",n,square,cube);
        }
}
/* EXERCISE: remove the & from &user_number, you will experience a core
dump. This is because scanf requires the & on the variable to read the data into. It
needs to be passed the address of where to write to */
/* UNIX PROGRAMMER'S HINT: when you have a program with a
            scanf in it,
            do a grep on the file with the scanf as the string to search for.
            Double check that every scanf has an & associated with it. If
            you know C shell programming, make a shell script to do the
            grep and print only the lines that have scanfs and not & */
```

If the & is left off, and if you use the highest warning level, the compiler should

warn you that

you are trying to use the value of the variable user_number before it has been set.

TRY TO GET INTO THE HABIT OF READING ALL WARNINGS FROM THE COMPILER! IT IS CONSIDERED GOOD PRACTICE THAT YOUR PROGRAM WHEN 'DONE' SHOULD CAUSE NO WARNINGS.

EXERCISE: see how large a number you can input and still get the square and cube of. Try to make the integer result go out of range

SCANF "Feature" or "Bug"

scanf always leaves a carriage return in the input stream. If you are mixing line input via scanf and character input via getchar, you will have to eat the carriage return left behind by the scanf or you will have to flush the input stream

| | | | | | |
|---|---|---|---|---|---|
| 89 | cr | 23 | cr | 'p' | cr |

**Using scanf for Input**

**scanf(" format_specifier" , address of variable to satisfy format_specifier);**

# prog12.c nested for loops

# "Ukranian doll for loops" "Matreshka"

```
/* program to calculate squares * /
/* introduces nested for loop */
main ( )
{
        int square, n, user_number, counter, i;
        /* this loop will be done four times */
        /*  counter will take on the values, 1 234 */
        for (counter = 1; counter < 5; counter++ )
        {
                printf("How far do you want to go to? \n");
                scanf("%i",&user_number);
                printf("\tYou entered %i \n\n",user_number); /* \f form feed */
                printf("TABLE OF SQUARES \n\n");
                printf("\t n \t n squared\n");
                printf("\t---\t----------\n");
                /* this loop will be done user_number times */
                /* n will take on values 1 through user_number */
                for (n = 1; n <= user_number; n++ )
                {
                        square = n * n;
                        printf("\t %i \t %i \n",n,square);
                        } /* end of n loop */
                } /* end of counter loop * /
                printf("\n\n");

                /*COMMON PROGRAMMING MISTAKES */
                for ( i = 0; i < 5; i++ )
                {
                  printf("outer i = %i \n",i);
```

```
        /* using same loop counter in a nested loop */
        for ( i = 6; i < 9; i++ )
        {
                printf("inner i = %i \n",i);
        }
        printf("\n\n");

        for ( i = 0; i < 5; i++ )
        {
                printf("outer i = %i \n",i);
                /* changing value of loop variable */
                i += 7;
        }
} /* end main */
```

# Assume i and j are ints

What Would be Printed?

```
for ( i = 0; i < 5; i ++ )
{ for (j = 5; j > 3; j-- )
{
        printf("%i %i\n" .i.j);
   }
}
```

# Assume x and m are ints

```
x = 5;
while ( x < 10) {
        m = x * 10;
        do {
                printf("%i %i \n" .x.m);
                m=m+ (m/2);
        } while ( m < 200 );
        x = x + 2;
 }
```

## prog13.c while loop

```
/* while loop * /
/* introduces \a, ansi alert character* /
main ( )
{
        int i;
        int sum = 0;
        i = -5;
        while ( i <= 5 )
        {
                printf("\a i = %i \n",i);
                sum += i;
                i++;
        }
        printf("Sum from -5 to 5 is %i \n",sum);

        /* COMMON PROGRAMMING MISTAKE */
        /* Infinite LOOP */
        i  = 1;
        EVERY C statement returns a value that may be used or ignored
        THE RETURN value of an assignment statement is the value assigned
        while ( i = 1 )
        {
                printf(" i = %i \n",i);
                i++;
                printf(" i = %i \n",i);
        }
  /* UNIX PROGRAMMER HINT */
  /* BEFORE COMPILING, AND ESPECIALLY BEFORE RUNNING */
  /*
            grep your file for all lines that have if, while, for in them
            double check that you have == where == is needed, and not =
            many programmers replace == with some other defined value
```

```
        see #define statement later
*/
/* add this line to top of program
#define MYEQ ==
then change the = in the while ( i = 1 ) to while ( i MYEQ 1 ) */
```

## prog14.c while loop for secret number guessing

```
/* while loops */
/* program to ask for guesses until they get it right */
main ( )
{
        int guess = -1;
        int secret = 7;
        int count of'guesses = 0;
        printf("Try to pick a number from 1 to 10 \n");

        /* possible infinite loop if user is real idiot */
        while ( guess != secret)
        {
                count of'guesses++:
                printf("Enter a guess \n");
                scanf ("%i",&guess);
                printf("\n You entered %i \n" ,guess);
        } /* end while */
        printf("You got it after %i tries \n",count_of_guesses);
}
```

## prog15.c  while loop vs. do loop

```
/* program to let user guess secret number */
/* shows difference between while loop and do
loop */
main ( )
{
        int guess;
        int secret = 7;
        int count_of_guesses = 1;
        printf("Try to pick a number from 1 to 10 \n");
        /* possible infinite loop if user is real idiot */
        /* need to preinitialize value for while loop */
        printf("Enter guess #%i\n",count_oCguesses);
        scanf ("%i",&guess);
        printf("\n You entered %i \n" ,guess);
        while ( guess ! = secret)
        {
                printf("WRONG\n");

                CONTROL will return from the system statement when the entire
                command has been completed. IF THE command was placed in the
                background
                control will return as soon as the placement has occurred

                system ("usr/demo/SOUND/play
                lusr/demo/SOUND/sounds/laugh.au");
                count_ of_guesses++:
                printf("Enter guess #
                %i\n",count_of_guesses);
                scanf ("%i",&guess);
                printf("\nYou entered %i \n",guess);
        } /* end while */
        printf("You got it after %i tries \n",count_oCguesses);
```

```
        printf("Try to pick a number from 1 to 10 \n");
        count_of_guesses = 0;
        secret = 3;
        /* do not need to preinitialize value for do loop */
        do
        {
                count_of_guesses++;
                printf("Enter guess #
                %i\n",count_of_guesses);
                scanf ("%i",&guess);
                printf("\n You entered %i \n"
                ,guess);
                if ( guess
                !=
                secret)
                {
                        printf("WRONG\n");
                        system ("/usr/demo/SOUND/play
                        /usr/demo/SOUND/sounds/laugh.au");
        } while ( guess != secret );
        printf("You got it after %i tries
        \n",count_of_guesses);
}
```

## Exercise 4

/* write a program to compute and print the first

ten * /

/* factorial numbers */

/* desired output is a table */

/* 1! 1 */

/*2! 2 */

/*3! 6 */

/* ... */

/* 10! 3628800 * /

If your program is more than 15 lines(of code, not counting comments) it is going the wrong

direction.

HINT: mathematical identity N! = (N-I)! * N

## Solution for Exercise 4

```
main ( )
{
        int i, factorial;
        factorial = 1;

        for ( i = 1; i <= 10; i++)
        {
                factorial = factorial * i;
                printf("%i!/t%i\n",i, factorial);
        }
}
```

## Exercise 5

/* write a c program to input an integer as an integer* /

/* print out the number, one digit per line */

/* i.e. input 1234 */

/* output 4 */

/* 3 */

/* 2 */

/* 1 */

## Solution for Exercise 5

```
main( )
{
        int i;
        int outnum;
        printf("Input number please \n");
        scanf("%i" ,&i);
        while (i > 0)
        {
                outnum = i % 10;
                printf("%i\n" ,outnum);
                i = i / 10;
         }
}
```

# C if if else

**if .c**

```
main ( )
{
        int i;
        printf("enter a number \n");
        scanf("%i",&i);

        if (i < 100)
        {
                printf("%i is less than one hundred \n",i);
        }
        printf("After the first if statement\n");

        if (i < l0)
        {
                printf("%i is less than ten \n",i);
        }
        else
        {
                printf("%i is greater than or equal to ten\n",i);
        }
}
```

**if (** relationalexpression **)**

```
{
        execute if re TRUE
        •••
}
```

**else /* must follow immediately */**

```
{
        execute if re FALSE
}
```

## prog16.c  math.h include file

```
/* if statement */
/* math.h contains mathematical functions like sqrtO */
#include <math.h>
main ( )
{
        float number;
        float square_root;
        printf("\n\nType in a number \n");
        scanf("%f",&number);
        printf("\nYou entered %f\n",number);
        if ( number < 0 )
        {
                printf("Can't get square root of negative number \n");
        }
        else
        {
                square_root = sqrt(number);
                printf("The square root of %f is %f\n",number,square_root);
        }
        printf'("Program completed \n");
 }
 /* EXERCISE remove the #include <math.h> line and see what you get */
 /* some (but not all) of the math functions available
   for a complete list, consult your compiler's documentation
        ceil(x) floor(x)
        sin(x) cos(x) tan(x) asin(x) acos(x) atan(x)
        sinh(x) cosh(x) tanh(x)
        exp(x) log (x) loglO(x) pow(x,y)
 */
```

# prog19.c logical operators and relational expressions

```
/* precedence of logical operators and
brackets * /
/*
<       less than
<=      less than or equal to
>       greater than
>=      greater than or equal to
==      equality
!+      inequality
&&      logical and
||      logical or

main ( )
  {
        int score;
        printf("Enter the score\n");
        scanf("%i",&score);
        printf("You entered %i\n",score);
        if ( score < 0 || score> 100 )
              printf(“Impossible score\n”);
        else
        {
              if ( score >= 0 && score < 50 )
                    printf("F\n");
              else
              {
                    if ( score >= 50 && score < 70)
                          printf(“D\n”);
                    else
                    {
                          if ( score >= 70 && score < 80)
```

```
                    printf("C\n");
                else if ( score >= 80 && score < 90)
                    printf("B\n");
                else if (score >= 90 && score <= 100)
                    printf("A\n");
                else
                    printf("no way to get here \n");
            }
        }
    }
}
```

**if ( relational expression)**

**relational expression evaluates to TRUE or FALSE**

**if ( (** r e 1**)** || **( r e 2) )**

**|| is the logical or operator**

| re1 | re2 | result |
|---|---|---|
| t | t | t |
| t | f | t |
| f | t | t |
| f | f | f |

**if ( relational expression)**

**relational** expression **evaluates to TRUE or FALSE**

**if ( ( re1) && ( re2) )**

**&& is the logical and operator**

| rel | re2 | result |
|---|---|---|
| t | t | t |
| t | f | f |
| f | t | f |
| f | f | f |

## prog20.c complex decision structures

```
#define         IBM     1
#define                 MER   2
#define                 MMD  3
#define                 QUIT  4
  main ( )
  {
        int stock symbol;
        char p_or_c;
        char cr;

        printf("\nEnter stock symboI\n");
        printf(" 1        IBM\n");       printf("2 MER \n”);
        printf("3         MMD\n");       printf("4 QUIT \n”);
        scanf("%i",&stock_symbol );
        scanf("%c",&cr);
        printf("You entered %i\n",stock_symbol);

        if ( stock symbol == IBM )
                printf("%.2f\n",53.25);
         else if ( stock_symbol == MER)
                printf("%.2f\n",71.75);
         else if ( stock_symbol == QUIT )
                printf("YOU SELECTED QUIT\n");
         else if ( stocksymbol == MMD )
         {
                printf("(P)referred or (C)ommon?\n");
                scanf("%c",&p_or_c );
                scanf("%c",&cr);
                  if (p_or_c == 'P' )
                  {
                          printf("Preffered 22.5\11");
                   }
```

```
            else if (p_or_c == 'c' )
            {
                printf(“Common 21.25\11");
            else
                printf("Unknown character \n");
    }
    else
    printf("Unknown symboI\n");
}
```

```
switch (discreet valued variable)
{
        case discreet value:
                        •••
                        •••
                        break;
        case discreet value:
                        •••
                        •••
                        break;
        •••
        •••
        default:
                        •••
                        •••
                        break;
 }
```

## prog21.c switch statement

```
#include <string.h>
#include <ctype.h>
#define     IBM    1
#define     MER    2
#define     MMD    3
#define     QUIT   4

int stock_symbol;
char p_or_c;
char cr;

printf(“\nEnter stock symbol\n");
printf(" 1     IBM\n");
printf("2      MER\n");
printf("3      MMD\n");
printf("4      QUTI\n");
scanf("%i",&stock_symbol );
scanf("%c",&cr);
printf(“You entered %i\n",stock_symbol);

switch ( stock_symbol )
{
        case IBM:
                printf("%.2f\n",53.25);
                break;
        case MER:
                printf("%.2f\n" ,71.75);
                break;
       case QUIT:
                printf("YOU SELECTED QUI1\n");
                break;
       caseMMD:
```

```
printf("(P)referred or (C)ommon?\n");
scanf("%c",&p_occ);
scanf("%c",&cr);
                if (toupper(p_or_c) ==  'P' ) /* this is an atrocious line of code
                */
                                                /* can you figure out why? */
              {
                    printf("Preffered 22.5\11");
                 }
                else if (toupper(p_or_c) == 'C' ) /* ATROCIOUS */
                {
                     printf("Common 21.25\n");
                }
              else
                     printf("Unknown character\n");
                     break;
        default:
               printf("Unknown symboI\n");
  } /* end switch */

  /* Exercise, remove the break in case IBM, what happens? Why? */
```

THESE TWO LINES ARE ATROCIOUS, yet common.

Why?

(toupper is a macro that converts a character to its upper case equivalent)

## Exercise 6

/* write a program to have a person guess a secret number.

Let the range of valid numbers be zero to 100.

Let them have a maximum of 7 tries.

Tell them if they were too high or too low.

Report the remaining range of possiblities for them */

## Solution for Exercise 6

```
main ( )

{
        int secret;
        int guess;
        int
        num_gu
        esses = 0;

        int hi =
        100;
        int lo =0;
        int seed;

      printf("What time is it hh:mm:ss\n");
      scanf("%i:%i:%i",&seed,&seed,&seed);
      srand( seed);   /* random number function */
      secret = (int) rand() / 330;
        if ( secret < 0 )
        secret = 0;
      if (secret> 100 )
        secret = 100;

        /* make sure that guess is incorrect to begin
 with */
        guess = secret - 1;
        while ( (secret != guess) && (num
        guesses < 7) )
        {
                num_guesses++;
                prfntf("Enter a guess between %i and %i\n",hi,lo);
                scanf("%i", &guess);
                printf("\nYou entered %i\n",guess);
```

```
                if
                ( guess
                <
                secret)

                {
                    system ("/usr/demo/SOUND/play
                    /usr/demo/SOUND/sounds/laugh.au");
                    printf("TOO LOW\n");
                    if ( guess > lo )
                        lo = guess;
                else if ( guess > secret)
                {
                    system ("/usr/demo/SOUND/play /usr/demo/SOUND/sounds/
                    laugh.au");
                    printf("TOO HIGH\n");
                    if ( guess < hi )
                        hi = guess;
                }
            }
        }
}
```

# Exercise 7

/* **FOR THE MATHEMATICALLY INCLINED** */

/* write a program to solve for the real roots of * /

/* the quadratic equation ax^2 + bx + c */

/* input a , b , c * /

/* check for real or imaginary roots * /

/* make sure not to divide by zero */

/* test data 1 2 1 => single real root x1 = -1 */

/* 1 -1 -6 => two real roots x1 = -2, x2 = 3 */

/* 0 0 0 => one real root x1 = 0 */

/* 0 4 -2 => one real root x1 = .5 */

xl = -1

xl = -2, x2 = 3

xl =0

xl =.5

## Solution for Exercise 7

```
#include <math.h>
main ( )
{
        float a, b, c;
        float discriminant;
        float xl, x2;

        printf("\n\ninput a b and c separated by spaces \n");
        scanf("%f %f %f',&a,&b,&c);
        printf("you entered %f %f %f\n\n\n",a,b,c);
        discriminant = ( b * b) - ( 4 * a * c);
        if ( discriminant> 0 )
        {
              if (a == 0)
              {
                if ( b == 0 )
                {
                        printf("x = 0 \n");
                else
                {
                        xl = (-c)/b;
                        printf("Single real root is %f\n",xl);
                }
        }
        else
        {
                xl = ( -b + sqrt(b*b - 4*a*c)) / (2 * a);
                x2 = ( -b - sqrt(b*b - 4*a*)) / ( 2 * a);
                printf("Two real roots are \n");
                printf("%f %f\n",xl,x2);
        }
```

```
        else if ( discriminant ==
        0 )
        {
                printf("one real root \
                n");
                if (a == 0 )
                 {
                        xl = 0;
                        printf("xl =
                        %f\n",xl);
                 }
                else
                 {
                        xl = -b / (2*a);
                        printf("xl =
                        %f\n",xl);
                }else
        {
                printf("Imaginary Roots\n");
        }
        printf("\n\n");
}/* end program */
```

# Exercise 8

```
/* exercise for those who don't want to do quadratic equations */
/* write a C program that:
        inputs an integer number from the keyboard
        displays it forwards
        displays it backwards  */

 /* big, brain buster
        as you reverse the number, print out each digit on a
        seperate line, with the english language word beside the digit */

 /* humungous brain destroyer
        print out the english word for the number as a whole
        i.e. 653 => six hundred fifty three
 */
```

## Solution for Exercise 8

```
/* write a c program to input an integer
 */
 /* print out the number, one digit per
 line */
 /* i.e. input 1234 */
/*       output 4
                3
                 2
               1 */                .
 /* then print it out in reverse order */
 /* then print the english word beside each digit */
 char * words[] = { "Zero", "Un", "Deux", "Trois", "Quatre", "Cinq", "Six",
 "Sept", "Huit", "Neuf"};

 /*
 solution
 */
 main ( )
 {
          int
          i,safe,outnu
          m;
          int revnum
          = 0;
          printf("Input number
          \n");
          scanf("%i",&i);
          while (i
          > 0)
          {
                   outnum = i % 10;                  /* strip off last digit */
                   revnum = revnum * 10 + outnum;
```

```
        printf("%i \n",outnum); /* print it */
        i = i /10;                      /* divide current number by 10
                                           effectively dropping last
                                           digit */
safe =
revnum;
printf("\n\
n");
```

```
 while ( revnum > 0 )
 {
        outnum = revnum % 10;  /* strip off last digit */
        printf("%i \n",outnum);  /* print it */
        revnum /= 10;
 }
 printf("\n\n");

/* now print digit by digit with english words */
while (safe > 0 )
{
        outnum = safe % 10; /* strip off last digit */
        printf("%i\t",outnum); /* print it*/
        printf(" % s\t",words [outnum]);

        switch( outnum)
        {
                case 0:
                        printf("Zero\
                        n");
                        break;
                case 1:
                        printf("One\
                        n");
                        break;
                case 2:
                        printf("Two\
                        n");
                        break;
                case 3:
                        printf("Three\
                        n");
                        break;
```

```
                case 4:
                        printf ("Four");
                        break;
                case 5:
                        printf("Five\
                        n");
                        break;
                case 6:
                        printf("Six\
                        n");
                        break;
                case 7:
                        printf("Seven\n);
                        break;
                case 8:
                        printf("Eight\
                        n");
                        break;
                case 9:
                        printf("Nine\n"); break;
        }
        safe /= 10; /* divide current number by 10 */
    }
}
```

## errors.c

```
/* putting a semi colon after a definition */
 #define MAX_VALUE                    100;

  /* forgetting that upper and lower case matter */
  #define ONE 0;
  main ( ) {
          int j  = 200; int k = 0;
          /* adding a semi-colon where there shouldn't be one */
         if( j ==  100);
                  printf("J = 100\n");
          /* leaving off a semi-colon where there should be one */

          /* won't compile because of #if 0 */
#if 0
         if( j ==  100)
         /* missing a semi-colon where you need one */
                  printf("l = 100\n")
         else
                  printf("J not equal to 100 \n");

          /* using one = where you need two == */
         if (j = MAX_VALUE )
                  printf("J was equal to MAX_ VALUE\n");
#endif
          /* putting = instead of == in a conditional */
          if(j = 1)
                   printf("J was equal to 1 \n");

          /* not using parantheses on math and forgetting */
          /* the precedence of operations */
          j  = 1 + 2 - 3 * 4/ 5 / 6 * 7 - 8 + 9;
          primf("J = %d \n",j);
```

```
#if 0
        j =  One;
        printf("j = %d \n",j);
#endif
        /* forgetting the & character in scanf calls will cause core dump * /
        printf("Enter value for j \n");
        scanf("%i", j);
        printf("You entered %i\n",j);
```

Here is a line of code actually found in a 'real' delivered product:

```
if (length = 8) length == 7; /* if length is 8 reset it to 7 */
```

it was quite interesting to determine what if anything to do with or about this ..

What would you have done??

## prog22.c simple array

```
/* introduces simple array */
/*  note that indexing goes from 0 to 4 */
/* declaration syntax indicates 5 cells */
/* starting at index 0 */
main( )
{
        int array1[5];
        int i;
        arrayl[0] = 23;
        array1[1] = 17;
        array1[2] = 29;
        array1[3] = 3;
        array1[4] = -7;
        for ( i = 0; i <= 4; i++ )
        {
                printf("array1[%i] = %i \n",i,array1[i]);
        }
        /*
        arrayl[0] = 23
        array 1 [1] = 17
        array1[2] = 29
        array 1 [3] = 3
        array 1 [4] =-7
        */
```

## Arrays: Discussion

To declare an array we state the type of its elements, the name of the array, and the number of elements in it:

int arl[l0];

defines storage for an array of 10 integers called arl.

Since all calls in C are call by value, what is the value of arl if we were to pass it to a function?

Mentioning arl with no subscript is to mention its address. This means the address of the first element in the array. When an array is subscripted, like: ar[1] = 42;

what actually happens is this, the compiler generates the code to take the starting address of the

array (the address of the zero-th element, arl), adds the size of 1 integer to it (to get the address of the element at location 1 in the array) and 'goes to' that address. In this case we are doing an

assignment operation, so the correct code is generated to perform a memory store at that address.

Since the compiler generates the address in this way, it assumes the programmer has verified that

the resulting address will be correct. **There are no array bounds checking in C, neither at com-**

**pile nor at run time!** Part of the reason for this is to maximize execution speed, the other is that

the authors wish to place the responsibility for (orrectness upon the programmer at design time.

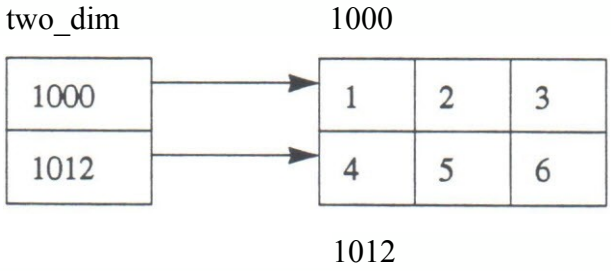
Other languages (like Pascal) enforce tight run-time checking.

Arrays may have more than 1 dimension:

int two_dim [2] [3l={ { 1,2,3 }, { 4,5,6} };

two_dim is a 2 by 3 array of integers. There are 2 rows of three columns.

Or we might say two_dim is an array of 2 3 integer arrays. In fact this is a better description as that is how it is stored remember, a 3 integer array is represented by its address. So two_dim has 2 entries in it each of which is the address where a 3 integer array begins in memory.




The statement two_dim[1][2] = 42; is compiled as:

Take the address in two_dim[1], add 2 integer sizes to it and go to that address and assign the

value 42 (1012 + (2 * 4) = 1020 the address of the third item in the second row)

## prog23.c array boundaries

```
main( )
{
        int array1[5] = { 23, 17, 29, 3,
        -7 };

        /* print out values in
        array */
        for (i = 0- i <= 4- i++)
                printf("arrayl[%i] = %i
                \n",i,arrayl[i]);

       /* print out values in array and beyond boundaries of
              array */
              for ( i = -4; i < 10; i++ )
                printf("arrayl[%i] = %i \n",i,arrayl[i]);
 }
/* sample output */
array 1 [0] = 23
array1[1] = 17
array1[2] = 29
array1[3] = 3
array 1 [4] =-7
array 1 [-4] = 3
array1[-3] = 16
array1[-2] = -2130509557
array1[-1] = -1
arrayl[0] = 23
array 1 [1] = 17
array1[2] = 29
array1[3] = 3
array 1 [4] =-7
array1[5] = 0
array 1 [6] = 0
array 1 [7] = 0
arrayl[8] = 0
array 1 [9] = 0
```

# prog25.c more array boundaries

```
/* note that values are assigned beyond declared
space */
main ( )
{
        int array 1[5];
        int i;

        /* valid initialization * /
        arrayl[0] = 23;
        arrayl[1]=l7;
        array1[2] = 29;
        arrayl[3] = 3;
        arrayl[4] = -7;

        /* these values are stored but can't be
        addressed */
        /* you can read from them but you can't
        write to them */
        /* because they are not part of your data
        space * /
        x = array 1 [5] = 24;
        array1[6] = 9848;
        array1[7] = -38495;

        for ( i = 0; i <= 7; i++ )
                printf("arrayl[%i] = %i
                \n",i,arrayl[i]);
/
 *sam
ple
output
array
1 [0]
= 23
arrayl
[l] =
17
array
1 [2]
= 29
array
1 [3]
= 3
array1
[4] =-
7
arrayl
[5] =
```

0
arrayl
[6] =
0
array1
[7] =
0
*/
QUESTION? Will x be set to 24 or 0?
Answer! 24, even though array 1 [5] is not set!
NOTE: on some systems (DOS for example) arrayl[5] may have been set to 24.
BEWARE: indexing outside array bounds can be very dangerous and causes many headaches for both new and seasoned C programmers. Sometimes this is refered to as having a "wayward pointer" meaning storing or retrieving data from who-knows-where. These can be particularly nasty bugs to debug. In this example storing at arrayl[5] will quite possibly overwrite the variable i. On many systems storing a value at arrayl[-l] will cause an addressing exception (mainframe).

## prog26.c bowling scores, array processing

```
/* program to calculate the average of a set of bowling
scores */
/* only count scores over 100 for person's average */
/* print out the high and low scores, all scores, scores used in
average*/
/* print out average */
#define         MAX_SCORES        100
#define         MAX_SCORE         300
#define         MIN_SCORE         0
#define         MIN_LEAGUE_SCORE      100
main ( )
{
        /* scores will be the array of scores entered * /
        int scores[MAX_SCORES];
        /* numscores is the count of how many scores they want to enter */
        int numscores, i, score;

        /* scores_to_count are used to keep track of how many valid scores there
        were */
        int raw _scores_to_count = 0;
        int league_scores_to_count = 0;
        int score_total = 0;

        /* the averages are floats because I want floating point
        accuracy */
        float raw_average;
        float league_average;

        /* initialize current high and low
        score */
        int high = 0;
        int low = MAX_SCORE;
```

```
        /* find out how many scores the person will be
        entering */
        printf("How many scores will you be entering?");
        scanf("%i", &numscores);
        printf("\nYou entered %d scores \n",numscores);
        if ( numscores >
        MAX_SCORES)
        {
                printf("CANNOT TAKE THAT MANY, %i is
                max\n",MNCSCORES);
                exit(-1);
        }
}
        /* for each of the scores requested, get the score */
        for (i = 1; i <= numscores; i++ )
        {
                printf(,'\nEnter score #%i: ",i);
                sc anf(" % i" ,&score );
                printf("You entered %i\n",score);
                /* if scores was less than 100 * /
                /* don't count in average */
                if ( ( score < MIN_SCORE ) || ( score> MAX_SCORE))
                        printf("Impossible score \n");
                else
                {
                        /* insert score into array */
                        scores [raw _scores_to_count] = score;

                        /* update the total of all scores */
                        score_total = score_total + score;
                        raw _scores~to_count++;
```

```
                if ( score > high)
                        high = score;
                if ( score < low)
                        low = score;
        } /* end for loop */
        if ( raw _scores_to_count > 0 )
        {
                raw _average = score_total/raw _scores_to_count;
                printf("\nRaw average = %.2f\n", raw_average);
                printf("High score was %i \n",high);
                printf("Low score was %i \n",low);
        }
        else
                printf("No valid scores entered\n");

        score_total = 0;
        league_scores_to_count = 0;
        printf("\n\nLIST OF LEAGUE SCORES USED IN AVERAGE\n");
        for ( i= 0; i  < raw _scores_to_count; i++ )
        {
                if (scores[i] > MIN_LEAGUE_SCORE )
                {
                        printf("\t%i\n" ,scores [i]);
                        league_scores_to_count++;
                        score_total += scores[i];
        if ( league_scores_to_count > 0 )
        {
                league_average = score_total / league_scores_to_count;
                printf("\nLeague average = %.2f\n",league_average);
        else
                league_average = 100;
} /*end main */
```

How many scores will you be entering?

You entered 10 scores

Enter score #1: You entered 100

Enter score #2: You entered 200

Enter score #3: You entered 300

Enter score #4: You entered - 3

Impossible score

Enter score #5: You entered 50

Enter score #6: You entered 100

Enter score #7: You entered 200

Enter score #8: You entered 300

Enter score #9: You entered 79

Enter score #10: You entered 407

Impossible score

Raw average = 166.12

High score was 300

Low score was 50

LIST OF LEAGUE SCORES USED IN AVERAGE

200

300

200

300

League average = 250.00

# prog27.c character arrays

**&s address of s**

**s value of s**

***s value stored at address stored in s**

```
/* program to illustrate initializing a character array */
/* will be initialized three different ways */
/* null terminator is added to word1 */
/* size of wordl would be determined at initialization time*/
int i,t;
char wordl[] =
{"abcdefghij"};
main ( )
{
        char word3[] = {"12345678901234567 89"};
        /* null terminator is not added to word2 */
        /* size of word2 would be determined at
        initialization time*/
        char word2[] = { 'H', 'e', 'l', 'l', 'O', '!' };
        char word4[] = {"ABCDEFGHIJKLMNOP"};
        /* null terminator is added to s size of s is size of pointer to char * /

        /* space for s is allocated at initialization time since the thing in double
                quotes must be stored somewhere The space for character string is
                made on stack */
        char * s = {"still yet another way, pointer to character"};
        for ( i = 0; i < 20; i++ )
                printf("%c %x\n", word1[i],
        word1[i] );
        printf("\n");

/* this is a really terrible thing to do, calling a subroutine over and over
        each time it is called it returns the same value. */
        for ( i  = 0; i < sizeof(word1); i++ )
```

```
        printf("%c", word 1 [i]);
printf("\n");

printf("%s",word1); /* this is
much better */
printf("\n") ;
for (i = 0; i < 20; i++ )
        printf("%c %x\n",
word2[i],word2[i]);
printf("\n");

t = sizeof(word2);
printf("sizeof word2
is %i \n",t);
for ( i = 0; i < t; i++ )
        printf("%c", word2[i]);
printf("\n");
printf("%s", word2);
printf("\n");

for ( i = 0; i < 20; i++ )
        printf("%c",s[i]);
printf("\n");

for ( i = 0; i < sizeof(s); i++ )
        printf("%c",s[i]);
printf('\n");

for ( i = 0; i < sizeof(*s); i++ )
        printf("%c" ,s[i]);
printf("\n");
printf("%s",s);
printf("\n") ;
```

}

**Output You'll See**

```
a 61
b62
c 63
d64
e 65
f66
g 67
h 68
i 69
j  6a
0
1 31
2 32
3 33
4 34
5 35
6 36
7 37
8 38
9 39

abcdefghij
abcdefghij
H 48
e 65
l6 c
l 6c
o 6f
! 21
1 31
2 32
3 33
4 34
5 35
6 36
7 37
8 38
9 39
0 30
1 31
2 32
3 33
4 34
 sizeof word2 is 6
 Hello!
 Hello! 1234567890123456789
 still yet another wa
 stil
 s
 still yet another way, pointer to character
```

## Exercise 9

```
/* write a program to input a list of numbers into an array */
/* print the array elements forwards and backwards */
/*
        Write a program to input a list of numbers into an array
        Find the largest element of the array
        Find the smallest element of the array
Put the smallest value at position 0 in the array and
                put the value that was at position 0 where the
                smallest value used to be
        Print out the updated array */
```

## Solution for Exercise 9

```
int main ( )
{
        int array[l0] = {1, 3,5, -2, -6, 7, 4, 9, 12,932 };
        int i, hipos, lopos, temp;
        hipos = lopos = 0;
        printf("Original Array \n");
        for ( i = 0; i < 10; i++ )
        {
                printf("Array position %i value %i
                'n",i,array[i]);
                if ( array[i] > array[hipos] )
                        hipos = i;
                if ( array[i] < array[lopos] )
                        lopos = i;
        }
        printf'(“Largest value is %i at index %i \n",array[hipos],hipos);
        printf("Smallest value is %i at index %i \n",array[10pos],lopos);

        /* switch lowest value to position 0, moving position 0 to where lowest came
        from */
        temp = array[lopos];
        array[lopos] = array[0];
        array[0] = temp;
        printf("Updated
        Array \n");
        for ( i  = 0; i < 10;
        i++ )
                printf("Array position %i value %i
                'n",i,array[i]);
} /* end main */
```

## Exercise 10

/* write a program to sort an array of
numbers */
/* use the array 1 35 -2 -67 49 12932
*/
/* sort the array from low to high */
/* print out the original and the sorted array */
/* DO NOT use a second array to sort the
numbers into,
you have to sort them in the array
they are in */
Note: you may implement the sort however you are
comfortable
The following is pseudocode for the so-called
bubble sort:

```
(ASSUMES ZERO BASED INDEXING)
FOR INDEX1 IS 0 TO NUMBER OF ELEMENTS IN
ARRAY-1
(from first to second to last)
    FOR INDEX2 IS INDEX1 +1 To NUMBER OF ELEMENTS IN
    ARRAY
    (from second to last)
      IF ELEMENT AT INDEX 1 IS GREATER THAN THE ELEMENT
                                  AT INDEX2
            SWAP ELEMENTS AT INDEX 1 AND INDEX2
    ENDIF
  ENDFOR
ENDFOR
```

## Solution for Exercise 10

```
main ( )
{
        int array[l0] = { 1,3,5, -2, -6, 7, 4, 9, 12,932 };
        int temp;
        int i,j;
        printf("Original unsorted array \n");
        for ( i = 0; i < 10; i++ )
        {
                printf("%i\t%i\n" ,i,array[i]);
        }
        for ( i = 0; i < 9; i ++ )
        {
                for (j = i + 1; j < 10; j++ )
                {
                        if ( array[j] < array [i] )
                        {
                                temp = arrayjj];
                                arrayjj] = array[i];
                                array[i] = temp;
                        } /* end if */
                } /* end for j loop */
        } /* end for i loop */
        printf("\n\nSorted Array\n");
        for ( i = 0; i < 10; i++ )
                printf("%i\t%i\n" ,i,arra y[i]);
}
```

## Function definition and prototypes

When we #include <stdio.h> what happens? The file stdio.h gets imbeddeed into our program.
The file stdio.h contains the prototypes for functions like printf (and other stuff).
A prototype is a declaration of what the interface for a function looks like. For printf it is:

```
unsigned printf(char *, ... );
```

This indicates that the printf function returns an unsigned int, and requires at least one argument, which must be a character string.

The compiler "remembers" the protytype after it "sees" it and will check our code to verify that
we are using it correctly. If we fail to pass printf at least a character string we will get a compiler
error. If we assign printf's return value to a non-unsigned, we will get at least a compiler warning.
When we write our own functions we will want to use prototypes to allow the compiler to provide the same type of checking as with printf.

If the compiler does not see a prototype for a function but sees it being used it will issue a warning and there will be no checking performed. This is deemed to be poor programming practice. We should always use prototypes to allow the compiler to verify our interfaces as well as our usage. A prototype is also known as a function declaration. To "declare" in C means to state that something exists (usually somewhere else).
The actual code for a function is called the function definition. To "define" in C means to create
code or storage.
Just as a note, many other languages support similar concepts as
prototypes.

## prog29.c elementary function declaration and usage

```
/* definition of subroutine */
/* should be defined before
it is used */
/* type of value it returns
        name
                type of arguments it expects */
/* program execution does not start here * /
/* this code is only executed when the subrl routine
is called */
void subr1(void) /* this is called the function
header */
 {
          printf("In
          subroutine\n"
          );
          return;
  }
/* this is where program
execution starts */
main( )
{
          /* declaring that main will call subr1 */
          /* function prototype header needs to go before first executable
          statement */
          void subr1(void);

          printf("In main
          routine \n");
          subr1( ):
          printf("Back in main routine \n");
}
```

/* sample output */

In main routine

In subroutine

Back in main routine

If we hadn't placed the prototype for subrl in main, the compiler by default woud assume that the function header correctly stated the return and parameter types. This only works because the compiler 'sees' the function definition in the same file as it is used. Again this is deemed poor style. If the definition for subrl was after main in the source file, we must place the prototype for subrl  before it's use in main. Leaving out the prototype wouldn't work as the compiler would not see the header line before it was used.

## prog30.c calling subroutines

```
/* definition of subroutine */
/* should be defined before it is used * /
/* type of value it returns
        name
                type of arguments it expects */
/* program execution does not start here */
/* this code is only executed when the subrl routine is called */
void subr1(void)
{
        printf("In subroutine\n");
        return;
}

/* this is where program execution starts */
main( )
{
        /* declaring that main will call subrlO */
        void subr1(void);
        printf("In main routine \n");
        subr1( );
        subr1( );
        subrl ( );
        printf("Back in main routine \n");
}
```

# prog31.c passing constants to subroutines

```
/* definition of subroutine, should be defined before it is used */
/* type of value it returns
        name
                type of arguments it expects */
/* program execution does not start here */
/* this code is only executed when the subrl routine is called */
void subr1(int n)  {
        /* n is a local variable (argument) who's purpose is to */
        /*  receive a copy of the parameter passed from main routine */
        /* i is a local variable it wi11live on stack */
        /* it will be deallocated when routine exits */
        int i;
        for ( i = 0; i < n; i++ )
                printf("In subroutine i = %i n = %i \n",i,n);
        return;
}
/* this is where program execution starts */
main( )
 {
        /* declaring that main will call subr1( ) */
        void subr1(int);
        printf("In main routine \n");
        /* calling subrl, sending 5 by value */
        subr1 (5);
        printf("Back in main routine \n");
 }
/* sample output */
In main routine
In subroutine i = 0 n = 5
In subroutine i = 1 n = 5
In subroutine i = 2 n = 5
In subroutine i = 3 n = 5
In subroutine i = 4 n = 5
Back in main routine
```

## prog32.c passing variables to subroutines

```
/* program execution does not start here */
/* this code is only executed when the subrl routine is called
*/
void subr1(int n)
{
        /* n is an argument passed from main routine, it is a local
        variable */
        /* i is a local variable, it will live on stack */
        /* it will be deallocated when routine exits, as will n
        */
        int i;
       /* static variable lives in data area, it's value */
       /* is retained between calls beware of static variables */
       /* in general, assume no static area is available */
       /* on some O/S, static variables are shared between all instances of the program
       */
       /* this defeats re-entrancy */
        static int j = 0;

        for ( i = 0; i < n; i+
                        + )
        {
                j++;
                printf("In subroutine i  = %d j  = %d \n",i,j);
        }
        return;
/* this is where program execution
starts */
main ( )
{
        int x;
        /* declaring that main will call
```

```
        subr1( ) */
        void subr1(int);
        x = 2; printf("In main routine x = %i
        \n",x);
        subr1(x);
        printf("Main routine location 1 x = %i \n\n",x);

        x = 3; printf("In main routine x = %i
        \n",x);
        subr1(x);
        printf("Main routine location 2 x = %i \n\n",x);

        x = -4; printf("In main routine x = %i
        \n",x);
        subr1(x);
        printf("Main routine location 3 x = %i \n\n",x);
}
/* EXERCISE */
/* WHAT WILL THE OUPUT
BE ?? */
```

**SOLUTION TO EXERCISE**

```
In main routine x = 2
In subroutine i = 0 j = 1
In subroutine i = 1 j = 2
Main routine location 1 x = 2
In main routine x = 3
In subroutine i = 0 j = 3
In subroutine  i  = 1 j  = 4
In subroutine  i  = 2 j  = 5
Main routine location 2 x = 3
In main routine x = -4
Main routine location 3 x = -4
```

# prog33.c subroutines returning values (void keyword)

```
/* routine will return no value, expects to receive an integer, will call integer
n */
void cube1 ( int n )
{int cube;   /* local variable for subroutine */
        cube = n * n * n;
        printf("Cube of %i is %i
        \n",n,cube);
        return;
}

/* routine returns an int, expects an integer, will call integer
n */
int cube2 ( int n )
{
        int cube;   /* local variable for subroutine */
        cube = n * n * n;
        return(cube);
}
main( )
{
        /* function prototype headers, not calls to subroutines */
        void cubel (int );
        int cube2 ( int );
        /* local variables for main */
        int input_value;
        int returned_value;
        printf("Enter number to calculate cube of\n");
        scanf("%i" ,&input_ value);
        printf("Calling cubel\n");
        /* there is no return value to catch */
        cubel(input value);

        printf("\nCalling cube2\n");
        /* there is a return value to catch */
        returned_value = cube2(input_value);
        printf("cube of %i is %i \n",inpuCvalue,returned_value);
}
```

# A Few Words About Multi-Module Programs

In the 'normal' programming world, we typically will not have just 1 giant source file. It makes more sense to have a file containing the main function, and one or more other files that contain functions typically grouped by functionality. Consider the three files test1.c funs1.c and funs2.c

test1.c

```
void main ( )
{
        f1( );
        f2 ( );
}
```

funs1.c

```
void f1 ( )
{
        f3 ( );
}
void f2 ( )
{
        some code
}
```

funs2.c

```
void f3 ( )
{
        some code
}
```

Since main calls nand f2 it should have the prototypes for these functions available to it at compile time. Likewise, since fl calls f3, it should have the prototype for f3 available to it. We could try to remember to do this. However, there is an easier way!

We can write our own header files (one or more):

myproto.h

```
void f1 (void);
void f2(void);
void f3(void);
```

Then we can load them all by using #include “myprot.h.”

test1.c

```
#include “myproto.h”
void main ( )
{
        f1( );
        f2 ( );
}
```

funs1.c

```
#include “myproto.h”
void f1 ( )
{
        f3 ( );
}
void f2 ( )
{
        some code
}
```

funs2.c

```
#incluee “myproto.h”
void f3 ( )
{
        some code
}
```

# including the prototype into funs2.c is important!

Even though function f3 does not call f1 or f2, the compiler will see the prototype for function f3. The compiler will verify that the prototype matches the actual code for the function

f3. If f3 were not coded with the correct number and type of parameters, or with the wrong return type (versus the prototype) the compiler would issue a warning.

This is yet another check that our promised interface (prototype) matches the actual code

we wrote and also how we will use it.

## prog35.c multiple files being compiled together

```
/* main routine located in one file * /
/* subrl is located in another file func35a.c */
/* subr2 is located in another file func35b.c */
/* compile together via
        acc -o prog35 prog35.c func35a.c func35b.c
*/
/* try acc prog35.c
   then try acc prog35.c func35a.c
   then try ace func35a.c func35b.c
        then try ace -c prog35.c
*/
/* this is where program execution starts */
main ( )
{
        /* declaring that main will call subrlO */
        void subr1(int);
        void subr2(int);
        printf("In main routine \n");
        subr1(5);
        printf("Main routine location 1\n\n");
        subr2(3);
        printf("Main routine location 2\n\n");
}
```

## func35a.c

```
/* program execution does not start here */
/* this code is only executed when the subrl routine is called */
void subr1(int n)
{
        void subr2(int);
        /* n is an argument passed from main routine * /
        /* i is a local argument, it will live on stack */
        /* it will be deallocated when routine exits */
        int i;
        for ( i = 0; i  < n; i++ )
        {
                printf("In subrl\n");
                subr2( -17);
                return;
        }
}
```

## func35b.c

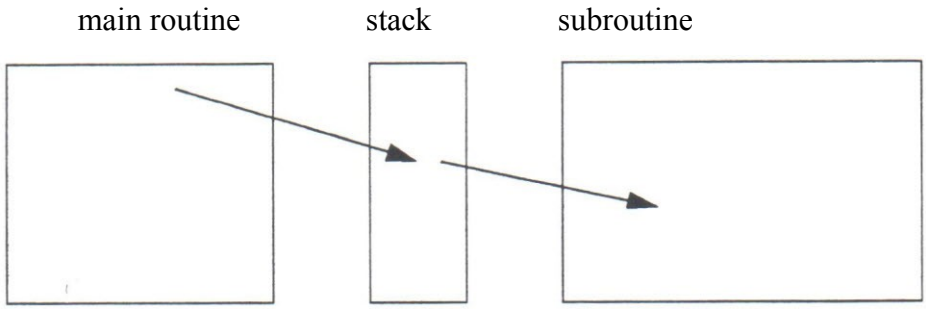
```
/* program execution does not start here * /
/* this code is only executed when the subrl routine is called */
void subr2(int n)
{
        /* n is an argument passed from main routine * /
        /* i is a local argument, it will live on stack */
        /* it will be deallocated when routine exits */
        printf("In subr2\n");
        printf("Square of %i is %i \n",n, n*n);
        return;
}
```

## valref.c Call By Value vs. Call by Reference

```
/* demonstrate call by value and call by reference */
void val1(int x)                        /* ansi function header
*/
 {
        x++;                            /* add one to x */
        printf("In vall x = %i \n",x);  /* print out its value */
        return;                         /* return to calling
routine */
 }

 void refl (int* x)       /* ansi function header */
 {
        *x = *x + 1;     /* add one to value stored at address stored in x */
        printf("In refl x = %i \n",*x);/* print it out */
        return;
}
main( )
{
        int i = 5;

        printf("In main i = %i \n",i);
        val1 (i);                       /* pass value of i to val1 */
        printf("In main i = %i \n",i);  /* notice that val1 did not change i */

        printf("In main i = %i \n",i);
        ref1(&i);                       /* pass address of i to ref1 */
        printf("In main i = %i \n",i);  /* notice that ref1 changed i */
}
In main i = 5
In val1 x = 6
In main i = 5
In main i = 5
In refl1x = 6
```

In main i = 6

**call by value**




values are placed on stack

subroutine cannot "see" memory of main routine

subroutine can only "see" values on stack

**call by reference**

addresses are placed on stack

subroutine can "see" memory of main routine through addresses found on stack

# Exercise 11

/* PART ONE */

/* write a program to input a number */

/*

Print the number in the main routine.

Pass the number to a subroutine by value.

Have the subroutine print the received value

Have the subroutine return twice the input value.

Have the main routine print the original and the result.

*/

/* PART TWO */

/* write a program to input a number */

/*

Pass the number to a subroutine by reference.

Have the subroutine multiply the value by three.

Have the main routine print the original value and the result.

*/

## Solution for Exercise 11

```
main( )
{
        int i;
        intj;
        int twice(int);
        void three_times(int *);

        printf("Enter number \n");
        scanf("%i",&i);
        printf("You entered %i \n",i);

        j = twice(i);
        printf("Twice %i is %i\n",i,j);

        printf(“three times %i is ",i);
        three_times(&i);
        printf("%i \n",i);
}

int twice( int n )
{
    return (n * 2 );
}

void three_times( int * nptr )
{
    *nptr *= 3;
    return;
}
```

## prog36.c

```
main ( )
{
        /* scores[0] is the zeroeth entry in scores */
        /* &scores[0] is the address of the zeroeth entry */
        /* scores all by itself, is semantically equivalent to &scores[0] */
        int scores[5], i;
        int determine 1 ( int values[5] );
        int determine2( int * );

        /* useful to use data file prog36.dat */
        printf("Please enter five scores \n");
        for ( i = 0; i < 5; i++ )
        {
                printf("Score %i: ",i);
                scanf("%i",&scores[i]);
                printf("\t %i \n",scores[i])

                if ( determine1 (scores) == 1 )
                        printf("23 was in array \n");
                else
                        printf("23 was not in array \n");

                if ( determine2(scores) == 1 )
                        printf("50 was in array \n");
                else
                        printf("50 was not in array \n");

                if ( determine3(scores) == 1)
                        printf("50 was in array \n");
                else
                        printf("50 was not in array \n");
        }
```

```
}
```

## prog36.c passing arrays to subroutines

```
/* write functions to find out if a value is in an
array */ #define          SUCCESS      1
#define          FAILURE      2
/* function returns an integer
*/
/* function name is
determine */
/* function accepts array of ten integers */
/* what it is really accepting is a pointer to the first element of the array */
int determine1 ( int values[5] ) {
        int i;
        for ( i  = 0; i < 5; i++ ) {
                if ( values[i] == 23 )
                        return(SUCCESS);
        }
        return(FAILU
        RE;

int determine2 ( int * x) {
int i;
        for ( i  = 0; i  < 5; i++ ) {
                if ( x[i] == 50 )
                        retum(SUCCESS );
        }
        return(FAILURE);
}
int determine3 ( int* x ) {
        int i;
        for (i = 0; i < 5; i++ ) {
                if ( *(x+i) == 50 )
                        return(SUCCESS);
```

```
        }
        retum(FAILURE);
}
```

# prog37.c passing pointers and arrays to subroutines

```
/* function to subtract every element by the element after
it* /
/* leave the last element alone */
/* this function demonstrates that array elements can
be */
/* manipulated by the function */
/* arrayptr is a pointer to an integer */
/* IT HAPPENS TO BE THE FIRST ELEMENT OF A TEN ELEMENT
ARRAY */
void subtracts( int • array _ptr )
{
        int i;
        for (i = 0; i < 9; i++ )
                array _ptr[i] = array _ptr[i] - array _ptr[i+ 1];
}

main ( )
{
        int scores[l0], i;
        void subtracts( int * );

        /* useful to use data file prog36.dat */
        printf("Please enter ten scores \n");
        for ( i = 0; i < 10; i++ )
        {
                printf("Score %i: ",i);
                scanf("%i",&scores[i]);
                printf("\t %i \n",scores[i]);
        }
        printf("Array before function call \n");
        for ( i = 0; i < 10; i++ )
                printf("scores[%i]\t%i\n",i,scores[i]);

        subtracts( scores );
        printf("Array after function call \n");
        for ( i = 0; i < 10; i++ )
                printf("scores [%i]\t%i\n",i,scores [i]);
}
```

## prog38.c  sorting an array of integers

```
/* function to sort an array of integers into ascending order */
/* problem is, we can't hard code the size of the array into the function */
/* first solution is to pass the size of the array into function */
/* function returns nothing */
/* its name is sort * /
/* it expects an integer array, doesn't know how big it will be yet */
/* n will be an integer specifying the size of the array */
void sort ( int *a, int n)
{
        int i,j,temp;
        for ( i = 0; i < n -1; i++ )
        {
                for (j = i + 1; j < n; j++ )
                {
                        if ( a[i] > a[j] )
                        {
                                temp = a[i];
                                a[i] = a[j];
                                a[j] = temp;
                        } /* end if */
                } /* end for j loop */
        } /* end for i loop */
} /* end sort function */

#define  MAX_ARRAY  100
/* main routine to call sort and display results */
main ( )
{
        int i;
        int num_elements;
        /* don't know how big array needs to be */
        int array[MAX_ARRAY] ;
```

```
        void sort( int *, int);
        /* get and error check number of elements */
        printf("How many elements in array'!\n");
        scanf("%i" ,&num_elements);
        if (num_elements < 0 ||  num_elements > MAX_ARRAY)
        {
                printf("Impossible number of elements\n");
                exit(-1);
        }
        /* have a good number of elements, continue */
        for ( i = 0; i < num_elements; i++ )
        {
                printf("Enter value for element %i \n",i);
                scanf(" %i ",&array[i]);
        }
        printf("The array before the sort is:\n");
        for ( i = 0; i < num_elements; i++ )
                printf("%i ",array [i]);
        printf("\n\n");

        /* call the subroutine to do the sort */
        /* pass the address of the array and number of elements */
        sort(array, num_elements);

        printf("The array after the sort is: \n");
        for ( i = 0; i < num_elements; i++ )
        printf("%i ",array[i]);
        printf("\n\n") ;
}
```

```
How many elements in array?
5
    Enter value for element 0
    1
    Enter value for element 1
    4
    Enter value for element 2
    2
    Enter value for element 3
    3
    Enter value for element 4
    9
    The array before the sort is:
    1 4 2 3 9
    The array after the sort is:
    1 2 3 4 9
```

## sortstep.c

```
void sortstep(int *, int, int);
main ( )
{
        int i,j;
        int array[3][4] =
        {
                { 0, 1,2,3 },
                { -1, -2, -3, -4 },
                { 10, 20, 30, 40 }
        };

        printf("array before call is \n");
        for ( i = 0; i < 3; i++ )
        {
                for (j = 0; j < 4; j++ )
                        printf("%3i ",array[i][j]);
                printf("\n");
        }
        sortstep (&array [0] [0],3,4);
        printf("array after call is \n");
        for ( i  = 0; i < 3; i++ ) {
                for ( j = 0; j < 4; j++ )
                printf("%3i ",array[i] [j]);
                printf("\n");
        }
        sortstep(&array[1] [0],4, 1);
        printf("array after call is \n");
        for ( i  = 0; i < 3; i++ )
        {
                for (j = 0; j < 4; j++ )
                        printf("%3i ",array[i][j]);
                printf("\n");
```

```
        }
}

void sortstep ( int *a, int n, int stepsize)
{
        int i, j, temp;
        int iindex, jindex;
        for ( i = 0; i < n -1; i++ )
        {
                iindex = i * stepsize;
                for (j = i + 1; j < n; j++ )
                {
                        jindex = j * stepsize;
                        if ( a[iindex] > a[ jindex ] )
                        {
                                temp = a[iindex];
                                a[iindex] = ajjindex];
                                aljindex] = temp;
                        } /* end if */
                } /* end for j  loop */
        } /* end for i loop */
} /* end sort function */
```

```
array before call is
0 1 2 3
-1 -2 -3 -4
10 20 30 40

array after call is
-1  1  2  3
0  -2 -3 -4
 10 20 30 40

array after call is
-1 1 2 3
 -4 -3 -2 0
 10 20 30 40
```

## prog39.c program to introduce two dimensional arrays

```
main( )
 {
        /* rc cola */
        /* rows, columns */
        /* 2 rows, three columns */
/* C THINKS OF SAMPLE_MATRIX AS AN ARRAY WITH TWO ENTRIES
                EACH ENTRY HAPPENS TO BE AN ARRAY OF THREE
                ENTRIES */
        /* sample_matrix[0] is an array, sample_matrix[0][0] is an
       integer */
       int sample_matrix[2] [3] =
                {
                        { 1,2
                        ,3 },
                        { 3,5
                        ,9 }
                } ;
        int row,column;
        int rowsum, colsum;

        /* print original matrix */
        printf("Original matrix
        \n");
        for ( row = 0; row < 2;
        row++)
        {
                for (column = 0; column < 3; column++ )
                                printf("%3i" ,sample_matrix[row][column]);
                printf("\n") ;
       }
       printf("\n\nMATRIX WITH ROWSUMS AND COLUMN
       SUMS\n");
       /* add up rows and columns, produce report */
       printf("\t\t rowsum\n");
       for ( row = 0; row < 2; row ++ )
        {
                rowsu
                m =0;
                printf("
                \t");
                for ( column = 0; column < 3; column++ )
                {
                        printf("%3i" ,sample_matrix [row ] [column]);
                        rowsum += sample_matrix[row][column];
                }
                printf(" %4i\n",rowsum);
       }
```

```
        printf("
        \n");
        printf("colsum\t");
        for ( column = 0; column < 3; column++ )
        {
                colsum = 0;
                for ( row = 0; row < 2; row++ )
                        colsum += sample_matrix[row] [column];
                printf("%3i" ,colsum);
        }
        printf('\n\n");
}

/* sample output */
/*
Original matrix
  1 2 3
  3 5 9
MATRIX WITH ROWSUMS AND COLUMN SUMS
                    rowsum
             1 2 3    6
             3 5 9    17
colsum       4 7 12
*/
```

## Sending Two Dimensional Array To Subroutine

# twodim.c

```
main( )
{
/* function prototype header must supply row and column
                information
                if we wish to use multiple sets of [] in subroutine */
         void s1( int a[2][3] );
        /* x all by itself is the address of the 1st array * /
        int x[2][3] =      /* x is an array with two elements, each element is itself an array
        */
         {
                {1,2,3},
                { 4,5,6}
         };
         printf(" AA \n");
         s1(x);  /* call using just name of array, resolves to &x[0], an array */

         printf("BB\n");
         sl(&x[0]);  /* call using address of first “array of arrays */

         printf("CC\n");
         sl(&x[0][0]);   /* call using address of first element of first array*
                         /* compiler warning b/c this is address of an integer, not an
array */
}

void s1(int x[2][3] )
/* converted to int**    */
{
         int i,j;
         for ( i = 0; i < 2; i++ )
         {
                for (j = 0; j
                < 3; j++ )
                {
                        /* function declaration informs us of how many rows and
                        columns */
                        printf("%i ",x[i] U] );
                }
                p
                ri
                n
                tf
                (
                "\
                n
                "
                );
```

```
        }
    }
```

## Solution for Exercise 13

```
/* function returns nothing * /
/* its name is sort * /
/* it expects an integer array, doesn't know how big it will be
yet */
/* n will be an integer specifying the size of the array */
void sort ( int a[ ], int n)
 {
        int i,j,temp;
        for (i = 0; i < n; i+
        + )
        {
                for (j = i  + 1; j < n; j++ )
                {
                        if ( a[i] > a[j] )
                        {
                                temp =
                                a[i];
                                a[i] =
                                a[j];
                                a[j] =
                                temp;
                        } /* end
                if */
                } /* end for j
                loop *
        } /* end for i loop */
} /* end sort
function *
```

```
#define  ROWS        3
#define COLS         4
main( )
{
        int input_array[ROWS][COLS];
        int temp_array[ROWS][COLS];
        int final_array[ROWS][COLS];
        int row[COLS], col[ROWS];
        void sort ( int a[ ], int n );
        int i,j;
        /* get and print original array */
        printf("\n");
        for (i  = 0; i < ROWS; i++ )
        {
                for (j = 0; j < COLS; j++)
                {
                        scanf("%i",&input_array[i][j]);
                        printf("%3i",input_array[i][j));
                }
                printf("\n");
        }

        for ( i = 0; i < ROWS; i++ )     /* sort by row */
        {
                for (j = 0; j < COLS; j++)
                        row[j] = input_array[i][j]:
                sort(row,COLS);
                for (j = 0; j < COLS; j++ )
                        temp_array[i][j] = row[j];
        }
        printf('\n\nAFfER SORTING ROWS\n"); /* print array */
        for ( i = 0; i < ROWS; i++ )
        {
```

```
                for (j = 0; j < COLS; j++ )
                        printf("%3i" ,temp
                _array[i] u]);
                printf('\n");
        }
        for (j = 0; j < COLS; j++ ) /* sort by column */
        {
                for ( i = 0; i < ROWS; i++ )
                        col[i] = temp_array[i][j];
                sort(col,ROWS);
                for ( i = 0; i < ROWS; i++ )
                        final_array[i][j] = col[i];
        }
        printf("\n\nAFTER SORTING COLS\n"); /* print array */
        for ( i  = 0; i  < ROWS; i++ )
        {
                for (j = 0; j < COLS; j++ )
                        printf("%3i" ,final_array[i][j]):
                printf'(“\n"):
        }
        printf('\n");
} /* end main */
```

**sample output**

```
 1 3 2 15
 3 8 0 2
 9 4 -3 12
AFTER SORTING ROWS
  1 2 3 15
 0 2 3 8
 -3 4 9 12
AFTER SORTING COLS
 -3 2 3 8
  0 2 3 12
  1 4 9 15
```

# More Array Syntax & Subroutines

## testarrays.c

The basic problem when communicating array information to a subroutine is how many rows
and how many columns, ( or how many entries per dimension) the array has. Basic pointer syntax only provides the address of the first element. This is fine if we wish to only traverse the
memory allocated for the array, however, if we wish to traverse it using the row and column layout we have specified when the array was created, we need to provide some row column information to the subroutine. As a rule, if there are N dimensions in the array you need to provide at least N-1 pieces of dimension information, the computer can figure out the last dimension. However, to be rigorous, why not provide as much as possible, all N if you know it. There are applications when you won't know the last dimension information.

```
void
s1(int *
x,int n)
{
        int i;
        for ( i = 0; i < n; i++ )
                printf("%5i", x[i]);
        printf("\n");
}

vo
id
s2
(in
t
x)
{
```

```
        printf("Ox%x",x);
        printf("\n");
}
```

```
main ( )
{
        void sl(int *,int );
        void s2(int);
        int one[5];
        int two[3][4]; two[0][0] = 0;
         two[0][1]  = 1
        two[0][2] = 2;
         two[0][3] = 3;

        two[1][0] = 10;
        two[1][1] = 11;
        two[1][2] = 12;
        two[1][3] = 13;

        two[2][0] = 100;
        two[2][1] = 101;
       two[2][2] = 102;
       two[2][3] = 103;

       one[0] = 0;
       one[l] = 1;
       one[2] = 2;
       one[3] = 3;

        printf("FIRST PRINT\n");
        sl(one,S);              /* array name by itself is pointer */
        sl(&one[2],3);          /* subscripted element needs & */
        s1(one + 2,3);          /* subscripted element needs & */

#if 0
        sl(one[2],3);   /* this would be run time error, subscripted element needs & */
#endif
```

```
        s2(one);   /* array name by itself is pointer, routine expecting int, prints it as int
*/
       s2(one[3]);       /* subscripted element is a value, routine expecting value, okay
*/
        printf("SECOND PRINT\n");
        sl(two,12); /* name of array by itself is pointer */
        sl(two[0],4); /* name of array by itself is pointer, two[0] is name of an array
                because two is an array of three elements,
                of which each element is itself an array */
        sl(two[1],4); /* name of array by itself is pointer */
        sl(two[2],4); /* name of array by itself is pointer */

#if 0
        sl(two[0][0],12);        /* subscripted element is value,
                                    routine expecting address, core
dump */
#endif
        sl(&two[0][0],12);              /* subscripted element needs & */
        s2(two);
        s2(two[0]);
        s2(two[1]);
        s2(two[2]);
        s2( two [0] [0]);
        s2(two[1][0]);
        s2(two[2][0]);
        s2(&two[0]);
```

SAMPLE OUTPUT

FIRST PRINT

0 1 2 3 4

2 3 4

Oxf7fffb34

Ox3

SECOND PRINT

0 1 2 3 10 11 12 13 100 101 102 103

0 1 2 3

10 11 12 13

100 101 102 103

0 1 2 3 10 11 12 13 100 101 102 103

Oxf7fffb04

Oxf7fffb04

Oxf7fffb14

Oxf7fffb24

OxO

Oxa

Ox64

0xf7fffb04

# Yet Even More Array Syntax & Subroutines

## test_arrays1.c

```
void s 1 (int * x,int n)
{
        /* will access as many as you say starting where you say */
        int i;
       for ( i  = 0; i < n; i++ )
        printf("%5i" ,x[i]);
       printf("\n");
}

void s2(int * x, int rows, int cols)
{
        /* wants to use multiple square brackets, needs dimension info */
        int i,j;
        for ( i = 0; i < rows; i++ )
        {
                for ( j = 0; j < cols; j++ )
                {
#if 0
                        /* this will be a compiler error */
                        /* routine does not have info on row,column
                        layout of memory associated with x */
                        printf("%4i ",x [i][j]);
#endif
                }
        }
}
```

```
void s3(int x[3][4],int rows,int cols )
{
        /* wants to use multiple square brackets, needs dimension info */
        int i,j;
        for ( i = 0; i < rows; i++ )
        {
                for (j = 0; j < cols; j++ )
                {
                        /* this will be a compiler error * /
                        /* routine does not have info on row,column
                        layout of memory associated with x */
                        printf("%4i ",x[i] [j]);
                        }
        }
}
```

```
main ( )
{
        void s 1 (int * ,int );
        void s2(int * ,int,int );
        void s3(int [3][4],int,int);

        int one[5];
        int two[3][4];
        two[0][0] = 0; two[0][1] = 1;
        two[0][2] = 2; two[0][3] = 3;
        two[l][0] = 10; two[1][1] = 11;
        two[1][2] = 12; two[1][3] = 13;
        two[2][0] = 100; two[2][1] = 101;
        two[2][2] = 102; two[2][3] = 103;
        one[0] = 0; one[1] = 1; one[2] = 2;
        one[3] = 3; one[ 4] = 4;

        /* call s 1 sending different lengths */
        printf("\ncalling s 1 \n");
        s1(one,5);
        s1(two,12);  /* will be compiler warning */
        s 1 (one, 10);

        /* try to call s2 , it won't work */
        printf("\ncalling s2 \n");
        s2(one,1,5);
        s2(two,3,4); /* will be compiler warning */
        /*  try to call s3 * /

        printf("\ncalling s3 for one\n");
        s3(one,1,5);/* will be compiler warning */
        printf("\ncalling s3 for two \n");
        s3(two,3,4);
        printf("\ncalling s3 for one\n");
        s3(one,2,4);/* will be compiler warning */
        printf("\n");
}
```

```
acc testarrays 1.c
 "testarrays l.c", line 70: warning: argument is incompatible with prototype: arg #1
 "testarrays1.c", line 76: warning: argument is incompatible with prototype: arg #1
 "testarrays1.c", line 80: warning: argument is incompatible with prototype: arg #1
 "testarraysl.c", line 84: warning: argument is incompatible with prototype: arg #1

 a.out
 calling sl
0 1 2 3 4
0 1 2 3 10 11 12 13 100 101 102 103
0 1 2 3 4 0 0 0 0 0

 calling s2
calling s3 for one
0 1 2 3 4
 calling s3 for two
 0 1 2 3 10 11 12 13 100 10 1 102 103
 calling s3 for one
 0 1 2 3 4 0 0 0
```

# prog40.c static, automatic, global keywords

```
/* two possible compile strings
        acc -D COMPVAR1 prog40.c additional code
        acc prog40.c            no additional code */

/* program to demonstrate static and automatic
variables */
/* program to demonstrate global variables */
/* we already did this once, do it again */
/* automatic variables go on the stack */
/* static variables go in data area */
int g; /* no initial value is assigned */

void subrl ( void)
{
        int local_ variable_is_auto = 1;
        static int local_ variable_is_static = 1;
        local_variable_is_auto++;
        local_ variable_is_static++;
        g++;
        printf("%i %i %i\n", local_ variable_is_auto, local_ variable_is_static,g);
}

main ( )
{
        void subr1 (void);
        g = 0;
        printf("Global variable = %i \n",g);
        subr1( );
        g++;
        subr1( );
#ifdef COMPVAR1
        local_ variable_is_auto++;
        local_ variable_is_static++;
        printf("%i %i %i\n", local_ variable_is_auto, local_ variable_is_static,g);
        printf("%i\n",g);
#endif
}
```

## Scope.c Scope of Variables

```
int i = 1;          /* global variable */
void subr1(void);
void subr2(void);
main ( )
{
        /* local i overrides global i * /
        int i  = 2;
        printf("AAA i = %i \n",i);

        /* call subroutine to test scope */
        subrl( );
        {
                int i  = -8032;
                printf("\tBBB i = %i \n",i);
        }

        /* call subroutine to test scope */
        subr2( );
}

void subrl( )
{
        /* local i overrides global i */
        int i = 23;
        printf("\tCCC( i = %i \n", i);
        {
                /* interior i overrides exterior i */
                int i = -98;
                printf("\t\tDDD i = %i \n",i);
        }
}


void subr2( )
{
        /* no local i, refers to global i */
        printf("\t\t\tEEE i = %i \n",i);
        {
                /* no local i, refers to global i */
                printf("\t\t\t\tFFF i = %i \n",i);
        }
}
```

AAAi=2

CCCi = 23

DDD i = -98

BBB i = -8032

EEEi = 1

FFFi= 1

**Definition:** recursive *adj.* see recursive[1]

# prog41.c Recursion

```
/* program illustrating recursive function */

/* recursive
function */
int
length(char
* s)
{
        printf("In length\n");
        if ( *s == '\0')
                return(1);
        else
                return(1 + length(s + 1) );
}

main ( )
{
        char
        string[20];
        printf("Enter a
        string \n");
        scanf("%s"
        ,&string);
        printf("You entered %s\n",string);
        printf("Its length is %i \n", length(string) );
}
```

Recursion can be misused. This is actually a poor example of 'tail recursion' (when the last thing
a routine does is call itself). Most tail-recursive programs are better written iteratively including

this one. Recursion is best used when the problem itself can be described in it's simpliest terms in a recursive manner (splitting a string in half, and in half etc), or the data structures involved may be viewed as recursive (binary trees, fractals)[2].

1. definition found in several sources, not possible to identify first author

2. See the book *Data Structures and Program Design in* C, for a good reference on recursion in C and guidelines on when to and not to use it. This book also contains a section in one appendix on removing recursion from programs.

```
 /* want these variables in read only memory */
 /* want to make sure their value doesn't change */
 /* during execution of program */
 /* they will not be on the stack */
 /* they are local to this routine */
 const double pi = 3.141592654;
 const char *cp = &buffer[0];

 /* want to prevent compiler from removing */
 /* optimizations of code * /
 /* if I did not have the volatile keyword here, the
        compiler would remove the second statement
        shown at location A below * /
 volatile char * out port;

 /* assign initial address to text pointer */
/* it now points to the zeroeth byte of the character array buffer * /
text pointer = &buffer[0];

/* i  and text pointer are in registers */
/* faster execution */
 for ( i = 0; i < 80; i++ )
        *text_pointer++ = 0x00;
```

```
    /* LOCATION A */
    /* this is code that is typical in device drivers
            of communication software, you want to write
            to bytes in a row to some chip through its port address * /
    /* an optimizing compiler would think that you
            changed the value at outport to OxOa and
            then changed it to OxOd, thus the first
            statement changing it to OxOa has no value,
            therefore an optimizing compiler would remove the
            first statement from the executable */
    /* the compiler would think that the first */
    /* assignment is useless and would optimize */
    /* it out of the code */
    /* the volatile prevents this */
    /* if out port was assigned to coml port Ox2f8 */
    /* and I said */
    /*  *out_port = OxOa; */
    /*  *out_port = OxOd; */
}
```

## speedl.c  Typical Inefficient Code

```
/* demonstrates some "usual" (and inefficient) ways things are done */
#ifdef          SPEED 1
main ( )
{
        int k.l:
        char buffer[2001];
        for ( k = 0; k < 10000; k++ )
        {
                for ( l = 0; l < 2000; l++ )
                {
                        buffer[l] = 0x00;
                }
        }
}
/* time to run 19.4u O.Os 0: 19 99% 0+132k O+Oio Opf+Ow */
#endif

/* compare the run time statistics for SPEED1 to SPEED2 (on next page ) */
```

```
#ifdef SPEED2
/* speed2.c */
/* demonstrates "faster" way things are done by more experienced programmers */
main ( )
{
        register int k;
        register int i;
        register char * b_ptr;
        char buffer[200 1];
        for (k = 0; k < 10000; k++)
        {
                b_ptr = &buffer[0];
                for (i = 0; i < 2000; i++ )
                {
                        *b_ptr++ = 0x00;
                }
        }
}
#endif
```

```
14.6u 0.0s 0:14  99% 0+132k O+Oio Opf+Ow
13.2u 0.0s 0: 13  99% 0+ 132k O+Oio Opf+Ow
10.0u 0.0s  0:10 99% 0+ 132k O+Oio Opf+Ow
7.6u 0.0s 0:08 99% 0+ 132k O+Oio Opf+Ow
```

## prog64.c copying strings using pointers

```
/* prog64.c copying strings using pointers */
/* this routine uses a pointer to specify where the data comes from
        and a pointer to specify where the data is supposed to end up
        it also uses pointer arithmetic in the copying loop,
        it has an inefficiency: whose correction is shown
                the test *from != '\0' is unneccessary
*/
void copy_1 (to, from)
char *to, *from;
{
        for ( ; *from != '\0'; from++, to++ )
                        *to = *from;
        *to = '\0';
}

/* copying strings using pointers is most efficient method
        effectively uses pointer arithmetic and implied tests */
void copy_2 ( to, from )
char *to, *from;
{
        /* remember C is an expression language and each statement
                        returns a value. In this case, we can use that
                        value to make our code more concise */
#if 0
        while ( *from )
                *to++ = *from++;
        *to = '\0';
#endif
        while ( *to++ = *from++ ) ;

char s 1 [] = "Terrill Owens";
char s2[40]; char s3[40];
```

```
char s4[40]; char s5[40];
char s6[ 40];

main( )
{
        printf("sl initially is %s\n",sl);
        copy_l(s2,sl);
        printf("s2 is now %s\n" ,s2);

        printf("s3 initially is %s\n",s3);
        copy_1 (s3,"C Programming is Totally Tubular");
        printf("s3 now is %s\n",s3);

        printf("s4 initially is %s\n",s4);
        copy_2(s4,sl);
        printf("s4 now is %s\n",s4);

        printf("s5 initially is %s\n",s5);
        copy_2(s5,"C Programming is Totally Tubular");
        printf("s5 now is %s\n" ,s5);

        printf("sl => %s s6 => %s \n",sl,s6);
        strcpy(s6,s 1);
        printf("sl => %s s6 => %s \n",sl,s6);
}
```

```
sl initially is Terrill Owens
s2 is now Terrill Owens
s3 initially is
s3 now is C Programming is Totally Tubular
s4 initially is
s4 now is Terrill Owens
s5 initially is
s5 now is C Programming is Totally Tubular
s 1 => Terrill Owens s6 =>
s 1 => Terrill Owens s6 => Terrill Owens
```

# Exercise 21

/* write a C function that will determine the length
of a user input string, use pointers and try to make it
as efficient as possible */

/* Use the strlen built-in function to check your work */

**Solution For Exercise 21**

```
/* edgar.c * /
int slength ( char * string ptr )
{
        char * cptr = string_ptr;

        while ( *cptr++ );

        return ( cptr - string_ptr - 1);
}

main( )
{
        int slength ( char * string );
        printf("%i ", slength(" 12345") );
        printf("%i ",  slength(""));
        printf("%i ",slength("12345678901234567890 12345") );
        printf("\n");
}
```

## prog73.c printf in depth

How to print integers

%i integer base 10

%o integer base 8

%x integer base 16

%u unsigned integer

%x integer base 16, lower case letters

%X integer base 16, upper case letters

%#x integer base 16, lower case letters, leading Ox

%#X integer base 16, upper case letters, leading OX

```
#define PR printf
main( )
{
        int prec;  float f;  int w;

        PR("lnteger Examples:\n");
        PR("\tbase 10 \tbase 8 \tbase 16\tunsigned int \n");
        PR("\t%i\t\t%o\t%x\t%u\n\n", 123, 123, 123, 123);
        PR("\tbase 16\t\tbase16 all caps\tbasel6 with leading x\tbasel6 with CAPS & X\
        n");
        PR("\t%x\t\t%X\t\t\t%#X\t\t%#X\n\n",1007,1007,1007,1007);
        PR("\tbase 10, sign\tbasel0, lead space, base 10 rjust, fw 7,0
        fill");
        PR("\t base 10,7 digits min fw\n");
        PR("\t%+i\t\t% i\t\t\t%07i\t\t\t\t% .7i\n\n", 1 ,2,3,4);

        PR("\nString Examples:\n");

        PR("\tpercent s only, string in field sized to fit\n");
```

```
PR("\1123456789012345678901234567890123456789012345678901234567890\n");
PR("\t%s\n\n","the quick brown fox jumped over the lazy dog");
PR("\tpercent .5s first five chars from string\n");
PR("\t1234567890123456789012345678901234567890123456789012345678901234567890\n");
PR("\t%.5s\n\n","the quick brown fox jumped over the lazy dog");
PR("\tpercent 30s at least thirty chars from string\n");
PR("\11234567 8901234567890123456789012345678901234567890 1234567890\n");
PR("\t%30s\n\n","the quick brown fox jumped over the lazy dog");
PR("\tpercent 20.5 s five chars, rjust in a field 20 wide\n");
PR("\t1234567890 12345678901234567890123456789012345678901234567 890\n");
PR("\t%20.5s\n\n","the quick brown fox jumped over the lazy dog");
PR("\tpercent - 20.5 s five chars, ljust in a field 20 wide\n");
PR("\t1234567890 1234567890 1234567890 1234567890 1234567890 1234567890\n");
PR("\t%-20.5sf\n\n","the quick brown fox jumped over the lazy dog");
```

```
    PR("Float Examples:\n");
    PR("\t7 .2f\1\17 .5f\t\t1.5f of 12345.67890\n");
    PR("\t  \n");
    PR("\t% 7 .2f \1%7 .5f\1% 1.5t\n\n", 12345.67890, 12345.67890,
    12345.67890);
    PR("\t7 .2f\1\17 .5fWl.5f of 1.2345\n");
    PR("\t  \n");
    PR("\t% 7 .2f \1%7 .5f\1% 1.5t\n\n", 1.2345, 1.2345, 1.2345);

    /* special cases where the precision is an argument */
    PR("Enter a float\n");
    scanf("%f" ,&f);
    PR("Enter number of digits after decimal to display\n");
    scanf("%i",&prec);
    PR("\n.....");
    PR("%.*t\n\n", prec,f);

    /* special case where the precision and total field width are an argument */
    PR("Enter a fioat\n");
    scanf("% f' ,&f);
    PR("Enter number of digits after decimal to display\n");
    scanf("%i" ,&prec);
    PR("Enter total field width \n");
    scanf("%i",&w);
    PR("    \n");
    PR("%*. *f\n", w,prec,f);

    PR("\nCharacters:\n");
    PR(" 123456789012345678901234567890123456789012345678901234567890\n");
    PR("%c%3c\n", 'W', 'W');
}
```

INTEGE

RS

| | |
|---|---|
| %+i | print the sign character |
| % i | force a leading space in front of a positive |
| %07i | right justified, 7 digit width, zero leading fill |
| %.7i | minimum field with 7 digits, right justified, leading zeroes |

FLOATS

| | |
|---|---|
| %8.2f | total field width eight, two decimal positions |
| %.*f",x,d) | default field width, x decimal positions |
| %*.*f',x,y,d) | total field width x, y decimal positions |

The Strings

| | |
|---|---|
| %s | null terminated string |
| %5s | first five characters (or until delimiter) |
| %.5s | first five characters ( forget delimiter) |
| %20.5s | five characters, right justified in 20 character field |
| %-20.5s | five characters, left justified in 20 character field |

scanf modifiers

| | |
|---|---|
| %s | read in a string delimited by ws or null |
| %5s | read in up to 5 characters delimited by ws or null |
| %5s: %5s$%5s | read in up to 5 characters until : delimiter<br>read in up to 5 characters until $ delimiter<br>read in up to 5 characters |
| %[abc]s | read in characters until ws, null or non abc encountered |
| %[^abc]s | read in characters until ws, null or abc encountered |
| %i %c | read in integer, consume ws, read in charater |
| % i%c | read in integer, do not consume ws, read in character |

# prog74.c scanf in depth

```
/* program to illustrate reading using scanf */

/* clearly demonstrates the next scanf picking up */
/* where the last scanf left off */
main ( )
 {
        char c;
        char s[60];
        int i;

        i = scanf("%c",&c);
        printf("i = %d c => %e\n",i, c);
        i = scanf("%s",s);
        printf("i = %d s => %s\n",i,s);

        i = scanf("%5s",s);
        printf("i = %d s => %s\n",i,s);

        i = scanf("%[abc]",s);
        printf("i = %d s=> %s\n",i,s);

        i = scanf("%[^abc]",s);
        printf("i = %d s => %s\n",i,s);
}
input file:
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz
 the alphabet abcdefghijklmnopqrstuvwxyz

program output
i = 1    c => t
i = 1    s => he
i = 1    s => alpha
i = 1    s => b
i = 1    s => et
```

## prog75.c scanf in depth

```
/* attempts to fix scanf idiosyncracies */
main ( )
{
        char c; char trash[80]; char s[80];
        int i; int j;
        char sl[80]; char s2[80]; char s3[80];

        /* read the first character into c * /
        /* read the rest of the line into trash */
        i = scanf("%c%[^\n]\n" ,&c,trash);
        printf("i = %d c => %c trash => %s\n",i, c, trash);

        /* clean out both of the buffers * /
        for ( i = 0; i < 80; i++ )
        {
                trash[i] = s[i] = 0x00;
        }

        i = scanf("%s%[^\n]\n",s,trash);
        printf("i = %d s => %s trash => %s\n",i,s);

        for ( i = 0; i < 80; i++ )
        {
                trash[i] = s[i] = 0x00;
        }

        i = scanf("%5s%[ ^\n]\n" ,s,trash);
        printf("i = %d s => %s trash => %s\n",i,s);
        for ( i  = 0; i < 80; i++ )
        {
                trash[i] = s[i] = 0x00;
        }
```

```
        i = scanf("%[abc]%[^\n]\n",s,trash);
        printf("i = %d s=> %s trash => %s\n",i,s);

        for ( i = 0; i < 80; i++ )
        {
                trash[i] = s[i] = 0x00;
        }

        i = scanf("%[^abc]%[^\n]\n",s,trash);
        printf("i = %d s => %s trash => %s\n",i,s);

        /* read the line as three white space separated strings */
        i = scanf("%s %s %s",sl,s2,s3);
        printf("sl => %s\n",sl);
        printf("s2 => %s\n",s2);
        printf("s3 => %s\n",s3);
}
```

input file

File Input Pointer

the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz
the alphabet abcdefghijk1mnopqrstuvwxyz

sample output

i = 2 c => t trash => he alphabet abcdefghijklmnopqrstuvwxyz
i = 2 s => the trash => alphabet abcdefghijklmnopqrstuvwxyz
i = 2 s => the trash => alphabet abcdefghijklmnopqrstuvwxyz
i = 0 s=> trash =>
i = 2 s => the trash => alphabet abcdefghijklmnopqrstuvwxyz
sl => the
s2 => alphabet
s3 => abcdefghijklmnopqrstuvwxyz

**Sample Run (Illustrates logical operations)**

```
Anding things together
And of
10001111
00000011
00000011

Oring things together
Or of
10001111
00000011
10001111

Xoring things together
Xor of
10001111
00000011
10001100

One's complementing things
One's complement of
10001111
01110000

One's complement of
00000011
11111100
```

# prog67.c Bit Operations

```
/* and                  &       */
/* inclusive or         |       */
/* exclusive or         ^       */
/* ones complement      ~       */
/* left shift           <<      */
/* right shift          >>      */
```

**disp_binary(c)**

```
char c;
 {
        int i;
        for ( i = 0; i < 8; i++ )
        {
                if (c & 0x80)
                        printf(" 1 ");
                 else
                         printf("0");
                 c = c << 1;     /* left shift c by one bit */
                                 /* the high bit shifted out goes in 'bit bucket' */
        }
        printf("\n");
}
```

```
main ( )
{
        char a,b,result;

        printf(" Anding things together \n");
        printf("And of\n");
        a = Ox8f;        /* 1000 1111 */
        disp_binary(a);
        b = Ox03;        /* 0000 0011 */
        disp_binary(b);
        result = a & b;          /* if either bit is zero, result is 0 */
        disp_binary(result);   /* if both bits are one, result is 1 */
        printf("\n");

        printf("Oring things together \n");
        printf("Or of\n");
        a = Ox8f;        /* 1000 1111 */
        disp_binary(a);
        b = Ox03;        /* 0000 0011 */
        disp_binary(b);
        result = a | b;                  /* if either bit is one,
        result is one */
        disp_binary(result);
        printf("\n");

        printf("Xoring things together \n");
        printf("Xor of\n");
        a = Ox8f;        /* 1000 1111 */
        disp_binary(a);
        b = Ox03;        /* 0000 0011 */
        disp_binary(b);
        result = a ^ b;          /* if only one bit is one, result is one */
        disp_binary(result);
```

```
printf("\n");

printf("One's complementing things \n");
printf("One's complement of\n");
a = Ox8f;          /* 1000 1111 */
disp_binary(a);
a = ~a;          /* switch 1 to 0, and 0 to 1 */
disp_binary(a);
printf("\n");

printf("One's complement of\n");
b = Ox03;          /* 0000 0011 */
disp_binary(b);
b = ~b;
disp_binary(b);
printf("\n");
```

## Exercise 22

/* write a c program that will accept a number from the user

display it in hexadecimal format then

display it in binary format, one bit at a time

each bit on a separate line */

## Solution For Exercise 22

```
/* bits.c */
/* input a positive integer number
        display it in hex
        display it in binary
        display it one bit per line, from high to low
        for added challenge, leave off any leading zeroes
*/
main( )
{
        int i,x,ptr;
        int last one;
        int bits[8 * sizeof(x)];

        printf("Enter number \n");
        scanf("%i",&x);
        printf("%i base 10 0x%x base 16 ",x,x);
        for ( i = 0; i < 8 * sizeof(x); i++ )
        {
                bits[i] = x & (int) 1;
                x = x >> 1;
                if ( bits[i] == 1 )
                        lastone = i;
        }
                while ( last_one >=  0 )
                        printf("%i" ,bits[last_one--]);

        printf(" base 2 \n");
}
```

```
Enter num ber
5
5 base 10       0x5  base 16            101 base 2

Enter number
127
127 base 10    Ox7f base 16            1111111 base 2
```

## prog71.c

## #ifdef compiler keyword conditional compilation

```
/* program to illustrate #ifdef */
/* this program will be compiled and run several times */
/* on each compile, I will define BEFORE or AFTER differently *
/* on each compile, I  will define BEFORE or AFTER differently */
main ( )
 {
        int i;
        int sum;

        sum = 0;
        for ( i = 0; i < 10; i++ )
        {
#ifdef BEFORE
        printf("before addition sum = %d i = %d \n",sum,i);
#endif
                sum = sum + i;
#ifdef AFTER
        printf("after addition sum = %d i = %d \n",sum,i);
#endif
        }
        printf("sum is %d \n",sum);
}
```

```
acc –o prog71 prog71.c
sum is 45

acc -D BEFORE -o prog71 prog71.c
before addition sum = 0 i = 0
before addition sum = 0 i  = 1
before addition sum = 1 i = 2
before addition sum = 3 i = 3
```

```
before addition sum = 6 i = 4
before addition sum = 10 i = 5
before addition sum = 15 i = 6
before addition sum = 21 i = 7
before addition sum = 28 i = 8
before addition sum = 36 i = 9
sum is 45

acc -D BEFORE -D AFfER -o prog71 prog71.c
before addition sum = 0 i = 0
after addition sum = 0 i = 0
before addition sum = 0 i = 1
after addition sum = 1 i = 1
before addition sum = 1 i = 2
after addition sum = 3 i = 2
before addition sum = 3 i = 3
after addition sum = 6 i = 3
before addition sum = 6 i = 4
after addition sum = 10 i = 4
before addition sum = 10 i = 5
after addition sum = 15 i = 5
before addition sum = 15 i = 6
after addition sum = 21 i = 6
before addition sum = 21 i = 7
after addition sum = 28 i = 7
before addition sum = 28 i  = 8
after addition sum = 36 i = 8
before addition sum = 36 i = 9
after addition sum = 45 i = 9
sum is 45
acc -D Before -D After  -o prog71 prog71.c
sum is 45
```

**Appendix: Warning about order of evaluation**

It is important (critical) to note that:

"the order of evaluation of subexpressions in a C expression where the order of evaluation is not defined is not defined".

This means that the statement:

a = b + c;

only implies that b and c are added and the result stored in a.

We can make no guarantee which will be retrieved first , a or b.

If we have 2 functions that return integers fl and f2:

```
int c;
c = f1( ) + f2( );
```

we cannot state which function, fl or f2, will be executed first.

likewise:

```
int  c = 7;
int a;
a = c + c++;
```

a will have either the value 14 (7 + 7) or 15 (8+7).

We cannot state which it will be and be sure that the answer will be the same on all systems.

```
int i = 9;
printf("%i %i", i, ++i);
```

will print either 9 10

or 10 10

this usually does not present any problems, but the programmer should be aware of it.

RECCOMMENDATION: NEVER make a second reference to a variable being modified in the same expression where the order of evaluation is undefined. Dennis Ritchie used to say that "such and such is undefined" What he meant was, "if you try to do the undefined thing then the results will most likely be something other than

what you expected". Then he would smile and say "Garbage In, Garbage Out", or sometimes just "GIGO"

## quicksort.c a quicksort example

```
#include <stdio.h>
#include <math.h>
#define MAXQUICK 128
int quick[MAXQUICK] /* array that holds the data */
int quickindex; /* index of how many elements there are */
FILE * fd; FILE * fd 1;

main ( )
{
        void printdata(void);
        void sortdata(int start pos, int end_pos);
        int intemp; int c;
        fd = fopen("datafile","r");
        if ( fd == NULL )
        {
                printf("open 1 failed \n");
                exit( -1);
        }

        fd1 = fopen("quickout" ,"w");
        if (fd1 == NULL )
        {
                printf("open2 failed \n");
                exit( -2);
        }

        /* input the data from file */
        quickindex = 0;
        while ( fscanf(fd, " %d", &intemp) != EOF)
        {
                /* store data in array */
                quick[quickindex++] = intemp;
```

```
        }
        quickindex--;

        /* print original list of data */
        printf("ORIGINAL LIST\n");
        printdata( );
        printf("\n\n");
        sortdata(0,quickindex);

        printdata( );
        close(fd); close(fdl);
}

void
printdata(void
)
{
        int i;
        fprintf(fd 1 ,"\n\n");
        for ( i = 0; i <= quickindex; i++ )
        {
                printf(" %d ",quick[i]);
                fprintf(fd 1, " %d ",quick[i]);
        }
        printf("\n\n");
        fprintf(fd1,"/n");
        return;
} /* end printdata
* /
```

```
#define         UP      0
#define         DOWN          1

void sortdata(int start_pos, int end_pos)
{
        int temp;
        int target_pos;
        int direction = DOWN;
        int in_end_pos;
        int in_start_pos;
        int temp_lower, temp_upper;

        in_start_pos = start_pos;
        in_end_pos = end_pos;
        target pos = start_pos;

        temp_lower = start_pos;
        temp_upper = end_pos;

        printf("SORTDATA %i %i \n",start_pos,end_pos);
        printdata( );
        fprintf(fdl,"SORTDATA %i %i \n",start_pos,end_pos);

       if ( start_pos >= end_pos )
                return;
       while (temp_lower < temp_upper)
       {
                if (direction == DOWN)
                {
                        if (quick[temp_upper] >= quick[target_pos] )
                        {
                                /* no update, move pointer */
                                temp_upper--;
```

```
                }
                else
                {
                        /* swap values */
                        temp = quick[temp_upper];
                        quick[temp_upper] = quick[target_pos];
                        quick[target_pos] = temp;
                        printdata( );

                        /* change direction of travel */
                        direction = UP;
                        /* change pointer to target value */
                        target_pos = temp_upper;
                }
        }
        else /* direction of travel is UP */
        {
                if ( quick[temp_lower] <= quick[target_pos])
                        temp _lower++;
                else
                {
                        /* swap values */
                        temp = quick[temp_lower];
                        quick[temp_lower] = quick[target_pos];
                        quick[target_pos] = temp;
                        printdata( );
                        /* change direction of travel */
                        direction = DOWN;
                        /* change pointer to target value */
                        target_pos = temp_lower;
                }
        }
} /* end while */
```

```
/* at this point the left and right pointers have met or crossed */
/* now we have divided our list into two segments */
        /* sort each of the smaller segments */

        /* RECURSION */
        /* do left side * /
        if ( in_start_pos < target_pos - 1 )
        {
                printf("Calling left side \n");
                sortdata(in_start_pos, target_pos - 1);
        }

        /* do the right side * /
        if ( target_pos + 1 < in_end_pos )
        {
                printf("Calling right side \n");
                sortdata(targetpos + 1 ,in_end_pos);
        }
        return;
} /* end sortdata * /
```

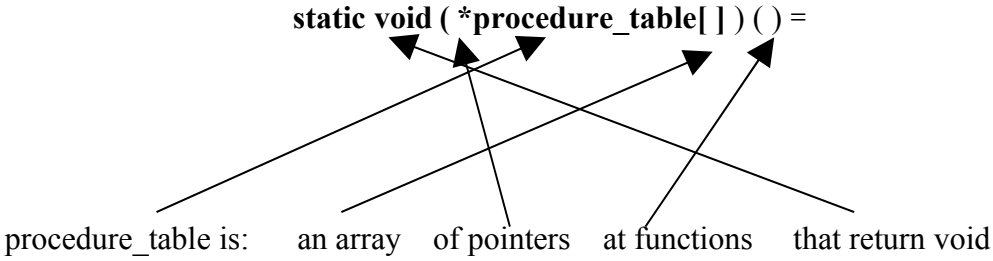
```
void exit( );

static void proca(fno,al,a2,a3,a4,aS)
int fno,al,a2,a3,a4,aS;
{
        int stat;
        stat = printf("In proca\n");
        if ( stat == 0 )
                exit(stat);

        stat = printf("%i %i %i %i %i\n",fno,al,a2,a3,a4,aS);
        if ( stat == 0 )
                exit(stat);
}

static void procb(fno,al,a2,a3,a4,aS)
int fno,al,a2,a3,a4,aS;
{
        int stat;
        stat = printf("In procb\n");
        if ( stat == 0 )
                exit(stat);
        stat = printf("%x %x %x %x %x %x\n",fno,al,a2,a3,a4,a5);
        if ( stat == 0 )
                exit(stat);
}
```

```
static void procc(fno,al,a2,a3,a4,a5)
int fno,al,a2,a3,a4,a5;
{
        int stat;
        stat = printf("In procc\n");
        if ( stat == 0 )
                exit(stat);
        stat = printf("%5i %5i %5i %5i %5i %5i\n",fno,al,a2,a3,a4,a5);
        if ( stat == 0 )
                exit(stat);
}

static void
( *procedure_table[ ]) ( ) =
{
        p
        r
        o
        c
        a
        ,
        p
        r
        o
        c
        b
        ,
        p
        r
        o
        c
        c
};
```

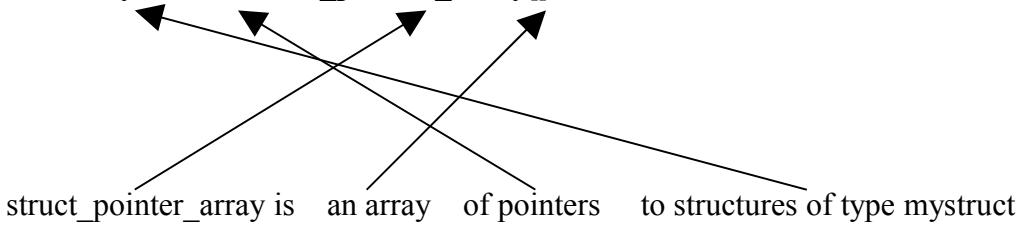
```
int main ( )
{
        int funcno, arg1, arg2, arg3, arg4, arg5;
        int i,stat;
        funcno = 0;
        argl = 100;
        arg2 = 200;
        arg3 = 300;
        arg4 = 400;
        arg5 = 500;

        stat = printf("In main
        routine \n");
        if ( stat == 0 )
                exit(stat);

        while ( funcno != -1 )
        {
                stat = printf(,'\nEnter function you wish to
                call\n");
                if ( stat == 0 )
                        exit(stat);
                stat = printf("-
                1\tquit\nO\tproca\n1\tprocb\n2\tprocc\n");
                if ( stat == 0 )
                        exit(stat);
                stat =
                scanf("%i",&funcno);
                if ( stat == 0 )
                        exit(stat);
                if (funcno != -1 && funcno >= 0 && funcno
                <= 2)
```

```
                {
                        (*procedure_table[funcno])
                        ( funcno,argl,arg2,arg3,arg4,arg5);
                }
        } /* end while */
        retur
n(0);
} /* end
main */
```

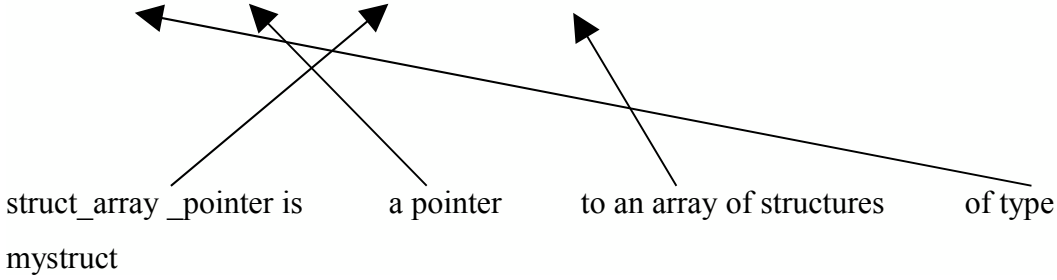
**Appendix: Reading complex declarations:**




**struct mystruct *struct_pointer_array[];**




**struct mystruct (*struct_array_pointer)[];**



**Appendix To Brace or Not To Brace**

```
main ( )
{
        int x;
        printf("Enter x \n");
        scanf("%i",&x);
        /* this decision structure is fully braced and indented in the KK style */
        if( x < 10)
        {
                printf("x less than ten \n");
        }
        else if ( x > 10 )
        {
                printf("x is greater than ten \n");
                if ( x < 100 )
                {
                        printf("x less than one hundred\n");
                }
                else
                {
                        printf("x is greater than or equal to 100\n");
                }
        else
        {
                printf("x is exactly ten \n");
        }

        /* this decision structure is not braced, indented only in KK style */
        if ( x < 10 )
                printf("x less than ten \n");
        else if ( x > 10 )
                if ( x < 100 )
                        printf("x less than one hundred\n");
```

```
            else
                    printf("x is greater than or equal to lCXJ\n");
    else
            printf("x is exactly ten \n");

    /* this decision structure removes the else from the nested if
            and introduces problem encountered when you leave off the braces */
    /* the last else belongs to the if ( x < 100 ) NOT the if (x < 10) */
    /* this could have been avoided by bracing */
    if ( x < 10)
            printf("x less than ten \n");
    else if ( x > 10 )
            if ( x < l00)
                    printf("x less than one hundred\n");
    else
        printf("x is exactly ten \n");

    /* this expression is indented and braced in a K&R like method */
    /* decide for yourself which style is most readable and MAINTAINABLE */
    if( x < 10){
            printf("x less than ten \n"); }
            else if ( x > 10 ) {
                    if (x < 100) {
                            printf("x less than one hundred\n"); }
                            else {
                                    printf("x is greater than or equal to 100\n"); } }
                                    else { printf("x is exactly ten \n"); }
}
```

```
Enter x          5
x less than ten
x less than ten
x less than ten
x less than ten

Enter x          11
x is greater than ten
x less than one hundred
x less than one hundred
x less than one hundred
x less than one hundred

Enter x          102
x is greater than ten
x is greater than or equal to 100
x is greater than or equal to 100
x is exactl y ten
x is greater than or equal to 100
```

NOTES:

Braces with only one statement within them are 'free' (no code overhead).

Experience has taught that there are times when a single statement within a loop or decision structure needs to have a debug statement added. This means that you have to add the braces anyway. Puting them in as an afterthought may lead to problems:

```
if ( value == 9 )          <-------- original code
   call function( );
```

```
if ( value == 9 )
   printf("if case true calling function");
   call_function( );       <-------- code with debug statement and added bug
```

code should look like this

```
if ( value == 9)
{
   call function( );
}
```

```
if ( value ==9 )           <-------- original code
{
   printf(“if case true calling function");
   call_function( );
}
```

**Appendix**

```
main ( )
{
        int i,j;
        int x[5] = { 1 , 2 , 3, 4, 5 };
        int y[2][3] = { {10,20,30}, {100, 200, 300} };
        printf("AAA \n");
        for ( i  = 0; i  < 5; i++ )
                /* this works as you'd expect */
                printf("%i ",x[i]);

        printf("\n\n");
        printf("BBB\n");
        for ( i= 0; i < 5; i++ )
                /* THIS ALSO WORKS !!! */
        /* compiler knows i is of type int and x is of type pointer to int
                and it generates the address correctly */
                printf("%i ",i[x]);

        printf("\n\n");
        printf("CCC\n");
        for ( i = 0; i < 2; i++ )

        {
                for ( j = 0; j < 3; j++ )

                {
                        /* this works as you'd expect */

                        printf("%i ",y[i][j]);
                }
                printf("\n");
        }
```

```
        printf("\n\n");
        printf("DDD\n")
        ;
        for ( i = 0; i < 2; i++ )

        {
                for ( j = 0; j < 3; j++ )
                {
                        /* THIS ALSO WORKS !!! */
                        /* compiler knows y is of type pointer to pointer to int
                                and i and j are of type int, figures out address correctly
                        */
                        printf("%i ",i[y][j]):
                }
                printf("\n");
        }

printf("\n\n");
#if 0
        /* this would be a compiler
        error */
        printf("EEE\n");
        for ( i = 0; i < 2;
        i++ )
        {
                for (j = 0; j < 3;
                j++ )
                {
                        /* THIS would not work, compiler error I DON'T KNOW
                        WHY */
                        printf("%i ",i[j] [y]);
                }
                printf("
                \n");
    }
 #e
ndi
f
}

AAA
12345

BBB
12345

CCC
10 20 30
100 200 300
```

DDD
10 20 30
100 200 300

# Crazy Address Stuff

```
int i;
int array[5];
for(i=0; i<5; i++
   )
   printf("%i
   \n", array[i]);

for(i=0; i<5; i++
   )
   printf("%i
   \n", i[array]);
```

Both these loops do the same thing: print out the contents of the array.
This is because array[i] is compiled as *(array+i) which is the same as *(i+array).

With a 2 dimensional array, the first index (major index) is itself an adderss, so in our example:

```
int i,j;
int y[2][3] = { {10,20,30}, {1
00,200,300} };
for ( i = 0; i < 2; i++ )
        for ( j = 0; j < 3; j++)
                printf("%i ",y[i]
        [j]);
```

y[i][j] means *( *(y+i) +j) where i is the offset into the array of row addresses and **j** is the offset into that row

```
for ( i = 0; i < 2; i++ )
        for ( j = 0; j < 3; j++ )
                printf("%i ",i[y][j]);
```

i[y][j] means *( *(i+y)+j) which also works since it generates the same address as in the previous example

```
for ( i = 0; i < 2; i++ )
        for ( j = 0; j < 3; j++ )
                printf("%i ",i[j][y]);
```

i[j][y] means *( *(i+j) +y) which results in a compiler error since we are attempting to add 2 integers (i and j) and then dereference them.

Some terminals don't have keys for (haracters that you may need in a C program.

The C language can handle this to a certain extent.

The mechanism employed to deal with this situation is the trigraph.

The following three keystrokes, when used together with no spaces between them, refer to the indicated character on their right.

This technique is useful in the 3270 enviroment because the [ and ] characters are not found on the 3270 keyboard.

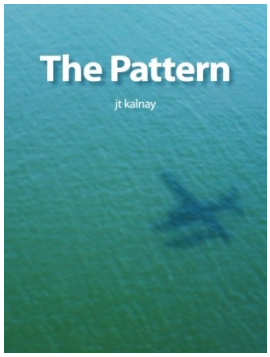
| **sequence** | |
|---|---|
| ??= | # |
| ??( | [ |
| ??) | ] |
| ??< | { |
| ??> | } |
| ??/ | \ |
| ??' | ^ |
| ??! | \| |
| ??- | ~ |

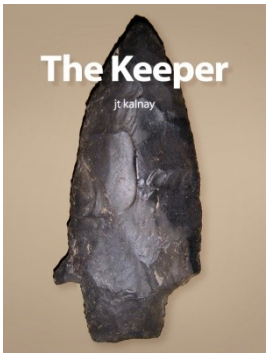
After JT Decided He Couldn't Write One More Program....

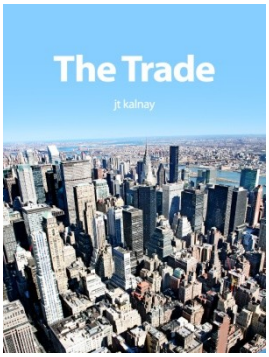
He Started Writing Novels,

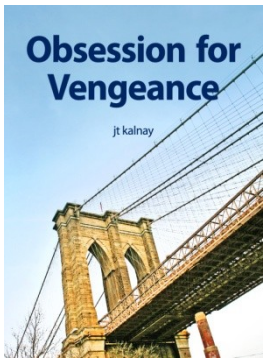
Please Consider Reading The Pattern (it's about a programming error)

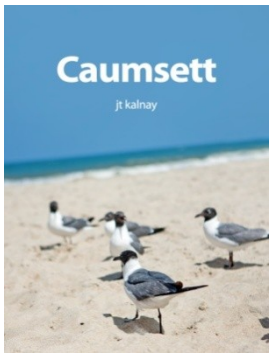
Or Consider Sampling Others of JT Kalnay's Novels

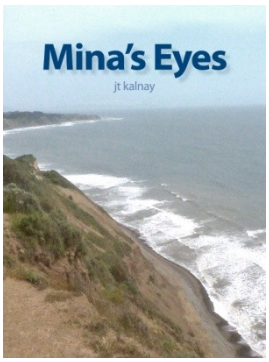


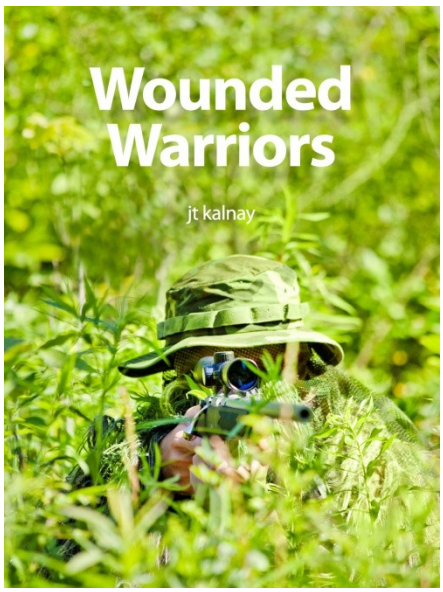



The first of JT Kalnay's works I've read, this early effort compares nicely with Ryan's "Adolescence of P-1" or Grisham's "The Firm" but wisely navigates around Powers' "Galatea 2.2" territory. You get a good sense this writer has "been there" but there is more to "The Pattern" than just an insider's view of an industry and culture that is pretty much a black box to those that haven't. This one gets a 4 out of 5 simply for not quite cracking the level of the big boys: Clancy, Ludlum, Cussler et al. Will be interested to see how this author develops in this genre.

I was surprised to enjoy this book so much as it comes from a not so well known author. Fantastic fiction.

I was thinking about the HAL 9000 malfunction in 2001 A Space Odyssey while reading The Pattern. Decades ago, I wondered if people would risk their lives on software. Now we have fly-by-wire controls in our airplanes and we depend on software in our hospital equipment as well as our cars. Software glitches can now kill. It's a really scary thought and I really enjoyed the thrilling journey the author takes us on in this techno-thriller treat. In the best spirit of science fiction it gives us pause to consider the dependency we freely give to our technology. In addition, as this story unfolds our humanity is laid bare in the face of technological realities that are seldom realized by most of us.

Please Enjoy This Sample From The Pattern

June 19, 1994

Chantilly Virginia

Assembled From News Wire Reports

A chartered executive Lear Jet inbound from Mexico City crashed today in heavy fog during final approach to Dulles National Airport in Washington D.C. Ten passengers and two crew members were killed instantly. There were no Americans on the flight and there were no survivors. Although the airplane had the latest electronics, it had aborted one landing due to the fog and was in the process of lining up for a second attempt when the accident occurred. The black box flight recorder has been recovered from the wreckage and the bodies have been identified. The last transmission from the cockpit was, "There seems to be something wrong with the electronics. Going around." The plane disappeared from radar less than ten seconds later.

June 20, 1994

San Francisco, California

Thin clouds drifted high above the city by the Bay. Craig and Stacey sat behind the APSoft building on the large cedar deck. A gentle breeze caressed Stacey's long, summer golden hair. Craig was having a very hard time concentrating on the report in his hands.

"Do you want to hear something weird?" Stacey asked.

"I don't know. Do I?" Craig answered.

"Yes. You do," Stacey said.

"Okay. Let's have it," Craig said.

"We're three for three this year," Stacey said.

"I don't get it," Craig said.

"On airplane crashes. We're three for three."

"I still don't get it," Craig said.

"Listen. First you know that guy in Turkey where the Blackhawks got shot down. Second, we both know Rakesh who's been in Hong Kong where the plane that crashed in Nagoya originated. Third, my friend in Mexico works for that company that chartered that plane that crashed in Virginia the other day. We're three for three."

"Better call the National Enquirer," Craig said.

"Jerk," Stacey said.

"We know somebody at almost every airline or aircraft manufacturer in the world Stacey. It'd be a miracle if we didn't know someone somehow related to every crash," Craig said.

"You're still a jerk," Stacey said.

"Yeah I know. It's part of my charm," he replied.

Stacey made a face at him and rolled her eyes.

"Please," she said.

"But you know what? You've piqued my curiosity. I'm going to do some research and see how many wrecks there have been in the last year. It does seem like there's been an unusual amount doesn't it?" Craig asked.

"Nice try," Stacey said.

"No. I'm totally serious. Now that you've pointed it out, I really am curious."

"Um huh," she said dismissively.

"Ready to throw it some more," Stacey asked, dangling Craig's birthday Frisbee on the end of a long slender finger.

"Not right now," Craig said. I better get started on that research.

http://jtkalnaynovels.wordpress.com/

www.jtkalnay.com


JT Kalnay is an attorney and an author. He has been an athlete, a soldier, a professor, a programmer, an Ironman, and mountain climber. JT now divides his time between being an attorney, being an author, and helping his wife chase after seven nieces and nephews.

JT was born and raised in Belleville, Ontario, Canada. Growing up literally steps from the Bay of Quinte, water, ice, fishing, swimming, boating, and drowning were very early influences and appear frequently in his work.

Educated at the Royal Military College, the University of Ottawa, the University of Dayton, and Case Western Reserve University, JT has spent countless hours studying a wide range of subjects including math, English, computer science, physics, and law. Many of his stories are set on college campuses. JT (along with MC and KR) is one of the founding members of the Stone Frigate Military Academy English Society.

JT is a certified rock climbing guide and can often be found atop crags in West Virginia, California, Texas, New Mexico, Nevada, Kentucky, Mexico, and Italy. Rock climbing appears frequently in his writing.

JT has witnessed firsthand many traumatic events including the World Trade Center Bombing, the Long Island Railroad Shooting, a bear attack, a plane crash, and numerous fatalities, in the mountains and elsewhere.

Disasters, loss, and confronting personal fear are common themes in his writing.

**www.jtkalnay.com**