C

C/C++ for Scientists and Engineers

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C OVERVIEW

Goals

- speed
- portability
- allow access to features of the architecture
- speed

C

- fast executables
- allows high-level structure without losing access to machine features
- many popular languages such as C++ , Java, Perl use C syntax/C as a basis
- generally a compiled language
- reasonably portable
- very available and popular

BASIC C PROGRAM STRUCTURE

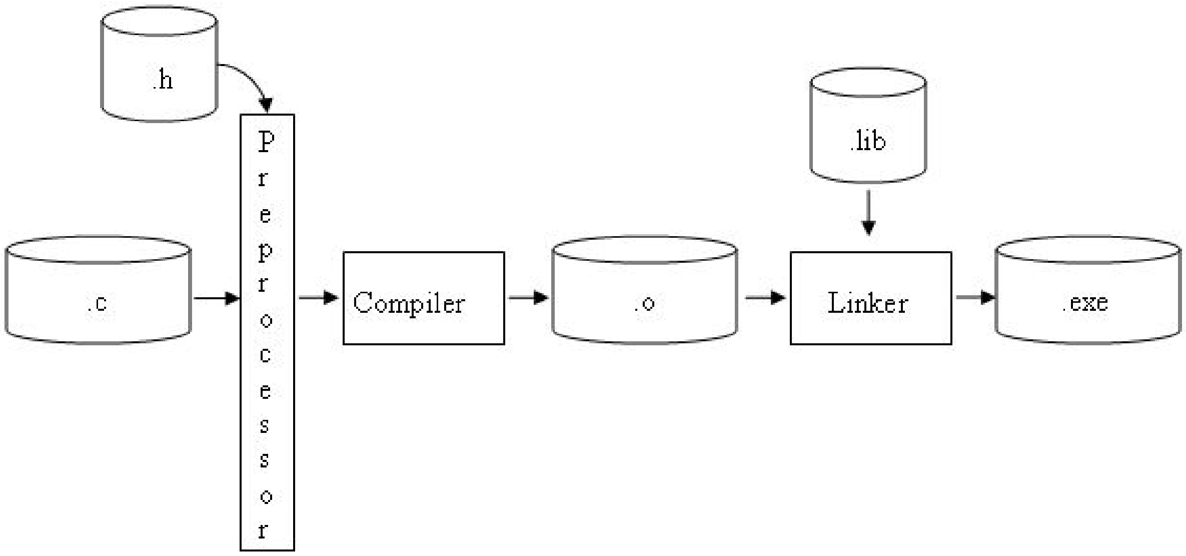
- The function main( ) is found in every C program and is where every C program begins execution.
- C uses braces { } to delimit the start/end of a function and to group sets of statements together into what C calls a block of code.
- Semicolons are used to terminate each C statement.
- Groups of instructions can be gathered together and named for ease of use and ease of programming. These “modules” are called functions in C.

Ex:

```
/*     FILE: first.c     */

#include <stdio.h>

int main( )
{
  printf("Hello world! \n");

  return 0;
}


/*    OUTPUT: first.c

          Hello world!

*/
```

COMPILING AND LINKING

- Producing an executable file from C source code involves a two step process, compiling and linking.
- The compiler translates the C code into machine code, the linker combines the new machine code with code for existing routines from available libraries and adds some startup code.
- The end result is a file full of machine instructions that are executable on the target machine.



Ex:

gcc first.c
- compile and link to a.exe

gcc -c first.c
- compile only, stop at object module

gcc -lm first.c
- link in math libraries

FUNDAMENTAL DATA TYPES

- there are three basic types of data, integer, floating-point, and character
- character data type is really a small integer
- signed and unsigned integer types available

Type	Size	Min	Max
char	1 byte	0 / -128	255 / 127
short	2 bytes	-32768	32767
int	2,4 bytes	-2147483648	2147483647
long	4 bytes	-2147483648	2147483647
long long	8 bytes	2^{63} ~ -9x10^{18}	2^{63}-1 ~ 9x10^{18}
float	4 bytes ~ 7 digits	$\pm 1.0\text{x}10^{-37}$	$\pm 3.4\text{x}10^{+38}$
double	8 bytes ~ 14 digits	$\pm 1.0\text{x}10^{-307}$	$\pm 1.8\text{x}10^{+308}$
long double	12 bytes ~ 20 digits	$\pm 1.0\text{x}10^{-4931}$	$\pm 1.0\text{x}10^{+4932}$

Ex:

```
/*     FILE: unsigned.c     */

/*
   Illustration of the unsigned keyword.  Allows
   recovering the use of the lead bit for magnitude.
*/
#include <stdio.h>

int main( )
{
  unsigned int x;

  x = 3333222111;

  printf("Unsigned x = %u\n", x);

  printf("Signed x = %d\n", x);

  return 0;
}


/*    OUTPUT: unsigned.c

          Unsigned x = 3333222111
          Signed x = -961745185

*/
```

COMMENTS

- Block-style comments /* … */   Everything between the opening /* and the first */ is a comment.
- Comment-to-end-of-line: //   Everything from the // to the end of the line is a comment.
- Nesting of block-style comments doesn’t work.
- Note: Some older compilers may not recognize the // comment indicator.

Ex:

```
/*     FILE: example.c     */

#include <stdio.h>

/* C-style comments can span several lines
   ...where they are terminated by:
*/

int main( )
{
  printf("Here's a program\n");

  return 0;
}


/*    OUTPUT: example.c

          Here's a program

*/
```

IDENTIFIERS

- C identifiers must follow these rules:
  - C is case sensitive
  - may consist of letters, digits, and the underscore
  - first character must be a letter, (could be underscore but this is discouraged)
  - no length limit but only the first 31-63 may be significant

KEYWORDS

auto	extern	short	while
break	float	**signed**	*_Alignas*
case	for	sizeof	*_Alignof*
char	goto	static	*_Bool*
const	if	struct	*_Complex*
continue	*inline*	switch	*_Generic*
default	int	typedef	*_Imaginary*
do	long	union	*_Noreturn*
double	register	unsigned	*_Static_assert*
else	*restrict*	void	*#_Thread_local*
enum	return	**volatile**	

BASIC INPUT AND OUTPUT

- The basic I/O functions are printf( ) and scanf( ).
- printf( ) and scanf( ) are very generic. They always are processing text on one end. They get all their information about the data type they are to print or scan from the conversion specifiers.
- printf( ) always is producing text output from any number of internal data formats, i.e. int, float, char, double. The job of the conversion specifiers is to tell printf( ) how big a piece of data it's getting and how to interpret the internal representation.
- scanf( ) always receives a text representation of some data and must produce an internal representation. It is the conversion specifiers job to tell scanf( ) how to interpret the text and what internal representation to produce.
- <u>printf( ) tips and warnings</u>:
  - ∗ Make sure your conversion specifiers match your data values in number, type and order.
  - ∗ Use %f for both float and double.
  - ∗ Everything you put in the format string prints exactly as it appears, except conversion specifiers and escape sequences.
- <u>scanf( ) tips and warnings</u>:
  - ∗ Make sure your conversion specifiers match your data values in number, type and order.
  - ∗ As a general rule, scan only one value with each scanf( ) call, unless you really know what you are doing.
  - ∗ Use %f for float, %lf for double and %Lf for long double.
  - ∗ Don't forget the &, except with strings. {Someday you'll know why that is, and it will make sense.}
  - ∗ For %c every character you type is a candidate, even <return>. Placing a space in front of the %c in the format string will cause scanf( ) to skip whitespace characters.
  - ∗ scanf( ) is NOT without it's problems. However, it provides an easy way to get text input into a program and has some very handy conversion capabilities.

CONVERSION SPECIFIERS

printf( )

%d	signed decimal int
%hd	signed short decimal integer
%ld	signed long decimal integer
%lld	signed long long decimal integer
%u	unsigned decimal int
%lu	unsigned long decimal int
%llu	unsigned long long decimal int
%o	unsigned octal int
%x	unsigned hexadecimal int with lowercase
%X	unsigned hexadecimal int with uppercase
%f	float or double [-]dddd.dddd.
%e	float or double of the form [-]d.dddd e[+/-]ddd
%g	either e or f form, whichever is shorter
%E	same as e; with E for exponent
%G	same as g; with E for exponent if e format used
%Lf,	
%Le,	
%Lg	long double
%c	single character
%s	string
%p	pointer

scanf( )

%d	signed decimal int
%hd	signed short decimal integer
%ld	signed long decimal integer
%u	unsigned decimal int
%lu	unsigned long decimal int
%o	unsigned octal int
%x	unsigned hexadecimal int
%f	float
%lf	double **NOTE:** double & float are distinct for scanf !!!!
%LF	long double
%c	single character
%s	string

ESCAPE SEQUENCES

- Certain characters are difficult to place in C code so an escape code or escape sequence is used to encode these characters.
- These escape sequences all begin with a backslash '\' and cause the encoded character to be placed into the program.

Escape	value
\n	newline
\t	tab
\f	formfeed
\a	alarm
\b	backspace
\r	carriage return
\v	vertical tab

Ex:

```
/*     FILE: print.c     */

/*
   Illustration of printf( ) and conversion specifiers.
*/
#include <stdio.h>

int main( )
{
  int x = 12;
  float y = 3.75;

  printf("%d", x);

  printf("\nx = %d\n", x);

  printf("y = %f\n", y);

  return 0;
}


/*    OUTPUT: print.c

          12
          x = 12
          y = 3.750000

*/
```

Ex:

```
/*     FILE: scan.c     */

/*
   Illustration of scanf( ).
*/
#include <stdio.h>

int main( )
{
  int x;
  float y;

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

  printf("y = %f\n", y);

  printf("Enter an integer value for x: ");
  scanf("%d", &x);

  printf("Enter a floating-point value for y: ");
  scanf("%f", &y);

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

  printf("y = %f\n", y);

  return 0;
}


/*    OUTPUT: scan.c

          x = 4206596
          y = 0.000000
          Enter an integer value for x: 7
          Enter a floating-point value for y: 3.3
          x = 7
          y = 3.300000

*/
```

Ex:

```
/*     FILE: scan2.c     */

/*
   Illustration of scanf( ) with characters and characters
   are integers.
*/
#include <stdio.h>

int main( )
{
  char c;

  printf("Enter a character: ");
  scanf("%c", &c);

  printf("c = %c\n", c);

  printf("c = %d\n", c);

  return 0;
}


/*    OUTPUT: scan2.c

          Enter a character: A
          c = A
          c = 65

*/
```

Ex:

```
/*     FILE: scan3.c     */

/*
   Illustration of interpretation caused by conversion specifiers.
*/
#include <stdio.h>

int main( )
{
  char c;
  int x;

  printf("Enter a character: ");
  scanf("%c", &c);

  printf("c = %c\n", c);

  printf("c = %d\n", c);

  printf("Enter an integer: ");
  scanf("%d", &x);

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

  printf("x = %c\n", x);

  return 0;
}


/*    OUTPUT: scan3.c

          Enter a character: 6
          c = 6
          c = 54
          Enter an integer: 6
          x = 6
          x = _

*/
```

OPERATORS

Arithmetic operators:

* / %	multiplication/division/modulus
+ −	addition/subtraction
+ −	positive/negative sign (unary)
++ − −	increment/decrement (unary)

Logical operators:

&&	AND
||	OR
!	NOT (unary)

Relational operators:

< <= > >=	less than, less than or equal to, greater than, greater than or equal to
= = !=	equal to and not equal to

Bit operators:

<< >>	left and right bit shift
&	bitwise AND
|	bitwise OR
^	bitwise exclusive or XOR
~	bitwise NOT (unary)

Assignment operators:

= += −= *= /= %= &= ^= |= <<= >>=

Address/Pointer operators:

&	address of (unary)
*	dereference (unary)

Structure operators:

.	structure member acccess
−>	member access thru a structure pointer

Other operators:

( )	function call
[ ]	array access
(*type*)	type cast (unary)
sizeof	data object size in bytes (unary)
?:	conditional operator
,	comma operator

OPERATOR PRECEDENCE

- The C compiler determines the order of operations in a C statement by operator precedence.
- Operator Precedence is the ranking of operators in C. The higher the rank the sooner the operator is evaluated.
- Parentheses can be used to override operator precedence.
- There are many kinds of operators but all operators are ranked via operator precedence.
- In the case of operators with the same rank, associativity is used and the operators are evaluated left-to-right or right-to-left.
- Operator precedence and associativity are detailed in the Operator Precedence Chart in the appendix, on the following page, and on pg. 53 in the K&R book

OPERATOR PRECEDENCE CHART

Operators	Associativity
( ) [ ] –> .	left to right *{( ) function call}*
! ~ ++ – – + – * & (*type*) sizeof	right to left *{All Unary}*
* / %	left to right
+ –	left to right
<< >>	left to right
< <= > >=	left to right
= = !=	left to right
&	left to right
^	left to right
|	left to right
&&	left to right
||	left to right
?:	right to left
= += –= *= /= %= &= ^= |= <<= >>=	right to left
,	left to right

ARITHMETIC OPERATORS

- Arithmetic operators are the symbols used by C to indicate when an arithmetic operation is desired.
- Arithmetic operators follow the same precedence rules we learned as kids. Multiplication & division before addition and subtraction. In case of a tie evaluate left-to-right. { Look at a precedence chart and see if this is true. }
- The modulus operator, %, is an additional arithmetic operator. It produces the remainder of integer division and ranks at the same level as division in the precedence chart.
- The increment, ++, and decrement, --, operators are basically a shorthand notation for increasing or decreasing the value of a variable by one.

Ex:

```
/*     FILE: arith_1.c     */

/* Arithmetic operators */

#include <stdio.h>

int main( )
{
  int first, second, sum;

  first = 11;
  second = 12;

  sum = first + second;
  printf("sum = %d\n", sum);

  sum = first - second;
  printf("sum = %d\n", sum);

  sum = first * second;
  printf("sum = %d\n", sum);

  sum = first / second;
  printf("sum = %d\n", sum);

  return 0;
}


/*    OUTPUT: arith_1.c

          sum = 23
          sum = -1
          sum = 132
          sum = 0

*/
```

Ex:
```
/*     FILE: arith_2.c     */

/* Arithmetic operators with nicer output */

#include <stdio.h>

int main( )
{
  int first, second, sum;

  first = 11;
  second = 12;

  sum = first + second;
  printf("%d + %d = %d\n", first, second, sum);

  sum = first - second;
  printf("%d - %d = %d\n", first, second, sum);

  sum = first * second;
  printf("%d * %d = %d\n", first, second, sum);

  sum = first / second;
  printf("%d / %d = %d\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_2.c

          11 + 12 = 23
          11 - 12 = -1
          11 * 12 = 132
          11 / 12 = 0

*/
```

Ex:

```
/*     FILE: arith_3.c     */

/* More arithmetic operators with nicer output */

#include <stdio.h>

int main( )
{
  int first, second, sum;

  first = 11;
  second = 12;

  sum = first + second;
  printf("%d + %d = %d\n", first, second, sum);

  sum = first - second;
  printf("%d - %d = %d\n", first, second, sum);

  sum = second - first;
  printf("%d - %d = %d\n", second, first, sum);

  sum = first * second;
  printf("%d * %d = %d\n", first, second, sum);

  sum = first / second;
  printf("%d / %d = %d\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_3.c

          11 + 12 = 23
          11 - 12 = -1
          12 - 11 = 1
          11 * 12 = 132
          11 / 12 = 0

*/
```

Ex:

```
/*     FILE: arith_4.c     */

/* Arithmetic operators with floating-point data */

#include <stdio.h>

int main( )
{
  float first, second, sum;

  first = 11;
  second = 12;

  sum = first + second;
  printf("%f + %f = %f\n", first, second, sum);

  sum = first - second;
  printf("%f - %f = %f\n", first, second, sum);

  sum = second - first;
  printf("%f - %f = %f\n", second, first, sum);

  sum = first * second;
  printf("%f * %f = %f\n", first, second, sum);

  sum = first / second;
  printf("%f / %f = %f\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_4.c

          11.000000 + 12.000000 = 23.000000
          11.000000 - 12.000000 = -1.000000
          12.000000 - 11.000000 = 1.000000
          11.000000 * 12.000000 = 132.000000
          11.000000 / 12.000000 = 0.916667

*/
```

Ex:

```
/*     FILE: arith_5.c     */

/* More arithmetic operators with floating-point data */

#include <stdio.h>

int main( )
{
  float first, second, sum;

  first = 1.35;
  second = 2.75;

  sum = first + second;
  printf("%f + %f = %f\n", first, second, sum);

  sum = first - second;
  printf("%f - %f = %f\n", first, second, sum);

  sum = second - first;
  printf("%f - %f = %f\n", second, first, sum);

  sum = first * second;
  printf("%f * %f = %f\n", first, second, sum);

  sum = first / second;
  printf("%f / %f = %f\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_5.c

          1.350000 + 2.750000 = 4.100000
          1.350000 - 2.750000 = -1.400000
          2.750000 - 1.350000 = 1.400000
          1.350000 * 2.750000 = 3.712500
          1.350000 / 2.750000 = 0.490909

*/
```

Ex:

```
/*     FILE: arith_6.c     */

/* Precedence of operators */

#include <stdio.h>

int main( )
{
  int first, second, sum;

  first = 10;
  second = 12;

  sum = first + second / 3;
  printf("%d + %d / 3 = %d\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_6.c

          10 + 12 / 3 = 14

*/
```

Ex:
```
/*     FILE: arith_7.c     */

/* Parentheses override precedence of operators */

#include <stdio.h>

int main( )
{
  int first, second, sum;

  first = 10;
  second = 12;

  sum = (first + second) / 3;
  printf("(%d + %d) / 3 = %d\n", first, second, sum);

  return 0;
}


/*    OUTPUT: arith_7.c

          (10 + 12) / 3 = 7

*/
```

Ex:

```
/*     FILE: computation.c     */

/* Computes the cost per sq inch of pizza
   -- inspired by pizza.c example in C
      Primer Plus by Prata                */

#include <stdio.h>

int main( )
{
  int diameter, radius, area, price, pricePerInch;

  printf("What is the price of your pizza: ");
  scanf("%d", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = diameter/2;
  area = 3.14159 * radius * radius;
  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %d\n", radius);
  printf("        area = %d\n", area);
  printf("       price = %d per sq. inch\n", pricePerInch);

  return 0;
}


/*    OUTPUT: computation.c

          What is the price of your pizza: 10.50
          What is the diameter of your pizza:
          Pizza analysis:
              diameter = 4206596
                radius = 2103298
                  area = -2147483648
                 price = 0 per sq. inch


          What is the price of your pizza: 10
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7
                  area = 153
                 price = 0 per sq. inch

*/
```

Ex:
```
/*     FILE: computation2.c     */

/* Computes the cost per sq inch of pizza

   Uses a float for price, to get dollars
   and cents.
                                          */

#include <stdio.h>

int main( )
{
  int diameter, radius, area, pricePerInch;
  float price;

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = diameter/2;
  area = 3.14159 * radius * radius;
  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %d\n", radius);
  printf("        area = %d\n", area);
  printf("       price = %d per sq. inch\n", pricePerInch);

  return 0;
}


/*    OUTPUT: computation2.c

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7
                  area = 153
                 price = 0 per sq. inch

*/
```

Ex:

```
/*     FILE: computation3.c     */

/* Computes the cost per sq inch of pizza

   More floating-point.
                                          */

#include <stdio.h>

int main( )
{
  int diameter;
  float price, radius, area, pricePerInch;

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = diameter/2;
  area = 3.14159 * radius * radius;
  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %f\n", radius);
  printf("        area = %f\n", area);
  printf("       price = %.2f per sq. inch\n", pricePerInch);

  return 0;
}


/*    OUTPUT: computation3.c

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7.000000
                  area = 153.937912
                 price = 0.07 per sq. inch


          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
              diameter = 18
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch


          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 19
          Pizza analysis:
              diameter = 19
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch

*/
```

Ex:

```
/*     FILE: computation4.c     */

/* Computes the cost per sq inch of pizza

   A type cast.
                                          */

#include <stdio.h>

#define PI 3.14159

int main( )
{
  int diameter;
  float price, radius, area, pricePerInch;

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = (float)diameter/2;
  area = PI * radius * radius;
  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %f\n", radius);
  printf("        area = %f\n", area);
  printf("       price = %.2f per sq. inch\n", pricePerInch);

  return 0;
}


/*    OUTPUT: computation4.c

          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
              diameter = 18
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch



          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 19
          Pizza analysis:
              diameter = 19
                radius = 9.500000
                  area = 283.528503
                 price = 0.05 per sq. inch

*/
```

INCREMENT ++/DECREMENT -- OPERATORS

- C has two specialized operators for incrementing and decrementing the value of a variable.

  ++ - will increase a variables value by “one”

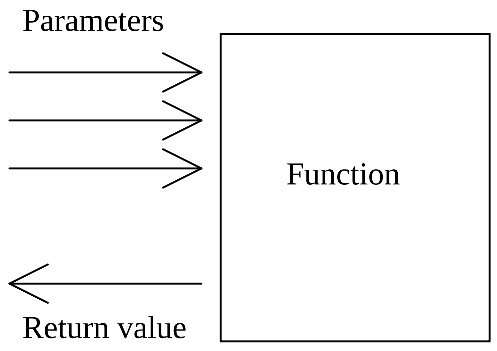
  -- - will decrease a variables value by “one”

- Both operators can be written in both prefix and postfix notation. Each has implications as to when the actual increment or decrement takes place. Fortunately the implications are reasonable. Prefix notation causes the increment/decrement to occur “before” the value of the variable is supplied to an expression. Postfix notation causes the increment/decrement to occur “after” the value of the variable is supplied to an expression. In all cases the variables value is increased/decreased by “one”

Ex:
```
/*     FILE: incDec.c     */

/* Example of increment & decrement, postfix and prefix. */

#include <stdio.h>

int main( )
{
  int i =7;

  printf("i = %d\n", i++);
  printf("After postfix ++, i = %d\n", i);

  printf("i = %d\n", ++i);
  printf("After prefix ++, i = %d\n", i);

  printf("i = %d\n", i--);
  printf("After postfix --, i = %d\n", i);

  printf("i = %d\n", --i);
  printf("After prefix --, i = %d\n", i);

  return 0;
}

/*    OUTPUT: incDec.c

          i = 7
          After postfix ++, i = 8

          i = 9
          After prefix ++, i = 9

          i = 9
          After postfix --, i = 8

          i = 7
          After prefix --, i = 7

*/
```

FUNCTIONS

- C allows a block of code to be separated from the rest of the program and named.
- These named blocks of code, or modules, are called functions.
- Functions can be passed information thru a parameter list and can pass back a result thru a return value.
- Any number of parameters can be passed to a function but at most one return value can be produced.
- All the C data types are candidates for parameter types and return types.
- Ideally a function can be treated as a black-box. If you know what to pass it and what it will return you don't need to know how it works.
- C has a special keyword, *void*, that is used to explicitly state that there are no parameters or no return value.



Ex:
```
/*     FILE: aFunction.c     */

/* Computes the cost per sq inch of pizza

   A function example. No parameters, no
   return value.
                                        */

#include <stdio.h>
#define PI 3.14159

void instructions(void);   /* Function prototype */

int main( )
{
  int diameter;
  float price, radius, area, pricePerInch;

  instructions( );  /* Call the instructions( )
                                 ... function         */

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = (float)diameter/2;
  area = PI * radius * radius;
  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %f\n", radius);
  printf("        area = %f\n", area);
  printf("       price = %.2f per sq. inch\n", pricePerInch);

  return 0;
}

void instructions(void)   /* Function definition */
{
  printf("This program will compute the price per \n");
  printf("square inch of a circular pizza.  \n\n");

  printf("It will prompt you for the price and the \n");
  printf("diameter of the pizza. Then it will display \n");
  printf("the results of its computations.\n\n");

  printf("Then compare several different price/size \n");
  printf("combinations to determine your best pizza \n");
  printf("value .\n\n");
}
```

cont…

```
/*    OUTPUT: aFunction.c

          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7.000000
                  area = 153.937912
                 price = 0.07 per sq. inch



          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
              diameter = 18
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch

*/
```

Ex:

```
/*     FILE: aFunction2.c     */

/* Computes the cost per sq inch of pizza

   Functions with parameter(s) and return
   value.
                                         */

#include <stdio.h>
#define PI 3.14159

void instructions(void);
float circleArea(float radius);

int main( )
{
  int diameter;
  float price, radius, area, pricePerInch;

  instructions( );  /* Call the instructions( )
                                 ... function         */

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = (float)diameter/2;

  area = circleArea(radius);  /* Call the circleArea( )
                                 ... function         */

  pricePerInch = price/area;

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %f\n", radius);
  printf("        area = %f\n", area);
  printf("       price = %.2f per sq. inch\n", pricePerInch);

  return 0;
}

void instructions(void)
{
  printf("This program will compute the price per \n");
  printf("square inch of a circular pizza.  \n\n");

  printf("It will prompt you for the price and the \n");
  printf("diameter of the pizza. Then it will display \n");
  printf("the results of its computations.\n\n");

  printf("Then compare several different price/size \n");
  printf("combinations to determine your best pizza \n");
  printf("value .\n\n");
}

float circleArea(float radius)
{
  float area;

  area = PI * radius * radius;

  return area;
}
```

cont…

```
/*    OUTPUT: aFunction2.c

          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7.000000
                  area = 153.937912
                 price = 0.07 per sq. inch



          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
              diameter = 18
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch

*/
```

Ex:

```
/*     FILE: aFunction3.c     */

/* Computes the cost per sq inch of pizza

   Functions with parameter(s) and return
   value.
                                          */

#include <stdio.h>
#define PI 3.14159

void instructions(void);
float circleArea(float radius);
float computePPI(float price, float area);

int main( )
{
  int diameter;
  float price, radius, area, pricePerInch;

  instructions( );

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  radius = (float)diameter/2;

  area = circleArea(radius);

  pricePerInch = computePPI(price, area);

  printf("Pizza analysis:\n");
  printf("    diameter = %d\n", diameter);
  printf("      radius = %f\n", radius);
  printf("        area = %f\n", area);
  printf("       price = %.2f per sq. inch\n", pricePerInch);

  return 0;
}

void instructions(void)
{
  printf("This program will compute the price per \n");
  printf("square inch of a circular pizza.  \n\n");

  printf("It will prompt you for the price and the \n");
  printf("diameter of the pizza. Then it will display \n");
  printf("the results of its computations.\n\n");

  printf("Then compare several different price/size \n");
  printf("combinations to determine your best pizza \n");
  printf("value .\n\n");
}

float circleArea(float radius)
{
  return PI * radius * radius;
}

float computePPI(float price, float area)
{
  return price/area;
}
```

cont…

```
/*    OUTPUT: aFunction3.c

          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
              diameter = 14
                radius = 7.000000
                  area = 153.937912
                 price = 0.07 per sq. inch



          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
              diameter = 18
                radius = 9.000000
                  area = 254.468796
                 price = 0.06 per sq. inch

*/
```

Ex:

```
/*     FILE: aFunction4.c     */

/* Computes the cost per sq inch of pizza

   Embedded function calls. (This is NOT
   necessarily the right way to do this.)

   main( ) has fewer variables, no need to
   store what you don't need.

   Functions have fewer variables.
                                        */

#include <stdio.h>
#define PI 3.14159

void instructions(void);
float circleArea(float radius);
float computePPI(float price, float area);

int main( )
{
  int diameter;
  float price;

  instructions( );

  printf("What is the price of your pizza: ");
  scanf("%f", &price);

  printf("What is the diameter of your pizza: ");
  scanf("%d", &diameter);


  printf("Pizza analysis:\n");
  printf("       price = %.2f per sq. inch\n",
           computePPI(price, circleArea((float)diameter/2)));

  return 0;
}

void instructions(void)
{
  printf("This program will compute the price per \n");
  printf("square inch of a circular pizza.  \n\n");

  printf("It will prompt you for the price and the \n");
  printf("diameter of the pizza. Then it will display \n");
  printf("the results of its computations.\n\n");

  printf("Then compare several different price/size \n");
  printf("combinations to determine your best pizza \n");
  printf("value .\n\n");
}

float circleArea(float radius)
{
  return PI * radius * radius;
}

float computePPI(float price, float area)
{
  return price/area;
}
```

cont…

```
/*    OUTPUT: aFunction4.c

          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 10.50
          What is the diameter of your pizza: 14
          Pizza analysis:
                 price = 0.07 per sq. inch



          This program will compute the price per
          square inch of a circular pizza.

          It will prompt you for the price and the
          diameter of the pizza. Then it will display
          the results of its computations.

          Then compare several different price/size
          combinations to determine your best pizza
          value .

          What is the price of your pizza: 15.50
          What is the diameter of your pizza: 18
          Pizza analysis:
                 price = 0.06 per sq. inch

*/
```

LOGICAL, TRUE/FALSE VALUES

- The C definition of true and false is that 0 is false and any non-zero value is true.
- This definition allows some unusual expressions to be used as test conditions.

RELATIONAL OPERATORS

- Relational operators are used quite often to produce the logical value for a conditional statement.

operator	function
= =	equality
<	less than
>	greater than
<=	less than or equal
>=	greater than or equal
!=	not equal

LOGICAL OPERATORS

- Logical operators work on logical values, i.e. true and false.

operator	function
&&	AND
||	OR
!	NOT

LOOPING

- C has three looping constructs, for, while, and do while.
- The while loop is a fundamental pre-test condition loop that repeats as long as the test condition is true.
- The for loop is just a specialized while loop that allows initialization and post-iteration processing to be specified adjacent to the test condition. It is the most commonly used loop in C.
- The do while is just a while loop with the test condition moved to the bottom of the loop. It is a post-test condition loop so the test is executed after each iteration of the loop. (The positioning of the test makes the timing clear.) The main feature of the do while is that it will always execute the body of the loop at least once.

Ex:
```
/*     FILE: for_1.c     */

/* for loop example. */

#include <stdio.h>

int main( )
{
  int i;

  for(i = 0; i < 10; i++)
  {
     printf("i = %d\n", i);
  }

  return 0;
}


/*    OUTPUT: for_1.c

          i = 0
          i = 1
          i = 2
          i = 3
          i = 4
          i = 5
          i = 6
          i = 7
          i = 8
          i = 9

*/
```

Ex:

```
/*     FILE: for_2.c     */
/* for loop example with adjustment for counting from 0. */

#include <stdio.h>

int main( )
{
  int i;

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

  return 0;
}

/*    OUTPUT: for_2.c

          i = 1
          i = 2
          i = 3
          i = 4
          i = 5
          i = 6
          i = 7
          i = 8
          i = 9
          i = 10
*/
```

Ex:

```
/*     FILE: while_1.c     */
/* while loop example. */

#include <stdio.h>

int main( )
{
  int i;

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

  return 0;
}

/*    OUTPUT: while_1.c

          i = 1
          i = 2
          i = 3
          i = 4
          i = 5
          i = 6
          i = 7
          i = 8
          i = 9
          i = 10

*/
```

Ex:

```
/*     FILE: loopChar.c     */

/* Reading characters in a loop.

   Note the space in front of the %c.
   It causes scanf( ) to skip leading
   whitespace characters.

   Ctrl/z produces an EOF from the
   keyboard on a PC.

*/

#include <stdio.h>

int main( )
{
  int ch;

  while(scanf(" %c", &ch) != EOF)
  {
     printf("character = %c\n", ch);
  }

  return 0;
}


/*    OUTPUT: loopChar.c

          character = a
          character = b
          character = c
          character = d
          character = F

       INPUT:

          a
          b

          c  d



          F

*/
```

Ex:

```
/*     FILE: loopChar2.c     */

/* Reading characters in a loop with
   getchar( ).

*/

#include <stdio.h>

int main( )
{
  int ch;

  while((ch = getchar( )) != EOF)
  {
     printf("character = %c\n", ch);
  }

  return 0;
}


/*    OUTPUT: loopChar2.c

          character = a
          character =

          character = b
          character =

          character =

          character = c
          character =
          character =
          character = d
          character =

          character =

          character =

          character =

          character = F
          character =


       INPUT:

          a
          b

          c  d



          F

*/
```

Ex:

```
/*     FILE: loopChar3.c     */

/* Reading characters in a loop with
   getchar( ).

*/

#include <stdio.h>

int main( )
{
  int ch;

  while((ch = getchar( )) != EOF)
  {
     if (ch != '\n' && ch != '\t' && ch != ' ')
       printf("character = %c\n", ch);
  }

  return 0;
}


/*    OUTPUT: loopChar3.c

          character = a
          character = b
          character = c
          character = d
          character = F

       INPUT:

          a
          b

          c  d



          F

*/
```

Ex:

```
/*     FILE: loopChar4.c     */

/*
   Reading characters in a loop with
   getchar( ).

   Using the isspace( ) function to skip
   whitespace.
*/

#include <stdio.h>
#include <ctype.h>

int main( )
{
  int ch;

  while((ch = getchar( )) != EOF)
  {
     if (!isspace(ch))
       printf("character = %c\n", ch);
  }

  return 0;
}


/*    OUTPUT: loopChar4.c

          character = a
          character = b
          character = c
          character = d
          character = F

       INPUT:

          a
          b

          c  d



          F

*/
```

MATH LIBRARIES

- C has a library of pre-defined mathematical functions.

Ex:

```
/*     FILE: math1.c     */

/* Program to compute the sine function for
   various values.                            */

#include <stdio.h>
#include <math.h>

int main( )
{
  double start, end, current, step, value;

  /* Set initial values */
  start = 0.0;
  end = 2 * M_PI;
  step = 0.01;

  /* Loop to compute and display values */
  for(current = start; current <= end; current += step){
    value = sin(current);
    printf("%f\n", value);
  }

  return 0;
}


/*    OUTPUT: math1.c

          0.000000
          0.010000
          0.019999
          0.029996
          0.039989
          0.049979
          0.059964
          0.069943
          0.079915
          0.089879
          0.099833
     .
     .
     .
          0.021591
          0.011592
          0.001593
          -0.008407
          -0.018406
          -0.028404
          -0.038398
          -0.048388
     .
     .
     .
          -0.023183
          -0.013185
          -0.003185

*/
```

Ex:

```
/*     FILE: math2.c     */

/* Program to compute the sine function for
   various values.

   Reads inputs.                            */

#include <stdio.h>
#include <math.h>

int main( )
{
  double start, end, current, step, value;

  /* Read initial values */
  scanf("%lf", &start);
  scanf("%lf", &end);
  scanf("%lf", &step);

  /* Loop to compute and display values */
  for(current = start; current <= end; current += step){
    value = sin(current);
    printf("%f\n", value);
  }

  return 0;
}


/*    OUTPUT: math2.c

          0.000000
          0.010000
          0.019999
     .
     .
     .
          0.021591
          0.011592
          0.001593
          -0.008407
          -0.018406
          -0.028404
     .
     .
     .
          -0.023183
          -0.013185
          -0.003185
          0.006815
          0.016814
          0.026811
     .
     .
     .
          0.024775
          0.014777
          0.004778

       INPUT:

          0.0
          9.4247779
          0.01

*/
```

Ex:

```
/*     FILE: math3.c     */

/* Program to compute various values using
   the power function.    pow( )             */

#include <stdio.h>
#include <math.h>

int main( )
{
  double start, end, current, step, value;

  /* Read initial values */
  scanf("%lf", &start);
  scanf("%lf", &end);
  scanf("%lf", &step);

  /* Loop to compute and display values */
  for(current = start; current <= end; current += step){
    value = pow(current,2.0);
    printf("%f\n", value);
  }

  return 0;
}


/*    OUTPUT: math3.c

          0.000000
          0.000100
          0.000400
     .
     .
     .
          88.172100
          88.360000
          88.548100
          88.736400

       INPUT:

          0.0
          9.4247779
          0.01

*/
```

CONDITIONAL STATEMENTS

- C has two conditional statements and a conditional operator.
- The basic conditional statement in C is the if. An if is associated with a true/false condition. Code is conditionally executed depending on whether the associated test evaluates to true or false.
- The switch statement allows a labeled set of alternatives or cases to be selected from based on an integer value.
- The conditional operator ?: allows a conditional expression to be embedded in a larger statement.

Ex:

```
/*     FILE: if.c     */

/* if examples. */

#include <stdio.h>

int main( )
{
  int i;

  i = 5;
  if(i > 0)
    printf("%d > 0\n", i);

  i = -2;
  if(i > 0)
    printf("%d > 0\n", i);
  else
    printf("%d <= 0\n", i);

  i = -2;
  if(i > 0)
    printf("%d > 0\n", i);
  else
    if(i == 0)              /* Test for equality is == */
      printf("%d == 0\n", i);
    else
      printf("%d < 0\n", i);

  return 0;
}


/*    OUTPUT: if.c

          5 > 0
          -2 <= 0
          -2 < 0

*/
```

Ex:

```
/*     FILE: switch.c     */

/* switch example. */

#include <stdio.h>

int main( )
{
  int ch;

  /* Display menu of choices */
  printf("\tA- append data\n");
  printf("\tD- delete data\n");
  printf("\tR- replace data\n");

  printf("\n\tQ- to quit\n");
  printf("\n\n\tChoice: ");

  ch =getchar( );

  /* Loop to quit on upper or lower case Q */
  while(ch != 'q' && ch != 'Q'){
    switch(ch){
      case 'a':
      case 'A':
         printf("Case 'Append' selected.\n", ch);
         break;
      case 'd':
      case 'D':
         printf("Case 'Delete' selected.\n", ch);
         break;
      case 'r':
      case 'R':
         printf("Case 'Replace' selected.\n", ch);
         break;
      default:
         printf("Invalid choice- '%c'.\n", ch);
         break;
    }

    getchar( );         /* strip trailing newline */

    /* Display menu of choices */
    printf("\n\n");
    printf("\tA- append data\n");
    printf("\tD- delete data\n");
    printf("\tR- replace data\n");

    printf("\n\tQ- to quit\n");
    printf("\n\n\tChoice: ");

    ch =getchar( );
  }

  return 0;
}
```

cont…

```
/*    OUTPUT: switch.c

                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: r
          Case 'Replace' selected.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: R
          Case 'Replace' selected.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: d
          Case 'Delete' selected.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: t
          Invalid choice- 't'.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: w
          Invalid choice- 'w'.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: q

*/
```

Ex:

```
/*     FILE: switch2.c     */

/* A function that displays info. */

#include <stdio.h>

void print_menu(void);

int main( )
{
  int ch;

  /* Display menu of choices */
  print_menu( );
  ch =getchar( );

  /* Loop to quit on upper or lower case Q */
  while(ch != 'q' && ch != 'Q'){
    switch(ch){
      case 'a':
      case 'A':
         printf("Case 'Append' selected.\n", ch);
         break;
      case 'd':
      case 'D':
         printf("Case 'Delete' selected.\n", ch);
         break;
      case 'r':
      case 'R':
         printf("Case 'Replace' selected.\n", ch);
         break;
      default:
         printf("Invalid choice- '%c'.\n", ch);
         break;
    }

    getchar( );         /* strip trailing newline */

    /* Display menu of choices */
    printf("\n\n");
    print_menu( );

    ch =getchar( );
  }

  return 0;
}

void print_menu(void)
{
  printf("\tA- append data\n");
  printf("\tD- delete data\n");
  printf("\tR- replace data\n");

  printf("\n\tQ- to quit\n");
  printf("\n\n\tChoice: ");

  return;
}
```

cont…

```
/*    OUTPUT: switch2.c

                A- append data
                D- delete data
                R- replace data

                Q- to quit


                Choice: r
          Case 'Replace' selected.


                A- append data
                D- delete data
                R- replace data

                Q- to quit


                Choice: D
          Case 'Delete' selected.


                A- append data
                D- delete data
                R- replace data

                Q- to quit


                Choice: q

*/
```

Ex:

```
/*     FILE: tracker.c     */

/* Program to read user input and track changes
   indicated by the user.                       */

#include <stdio.h>

void printMenu(void);
void printStatus(int, int);

int main( )
{
  int x=0, y=0;
  int ch;

  printStatus(x,y);  /* Print current x,y  */

  /* Display menu of choices */
  printMenu( );
  ch =getchar( );

  /* Loop to quit on upper or lower case Q */
  while(ch != 'q' && ch != 'Q'){
    switch(ch){
      case 'u':
      case 'U':
         printf("Case 'Up' selected.\n", ch);
         y++;
         break;
      case 'd':
      case 'D':
         printf("Case 'Down' selected.\n", ch);
         y--;
         break;
      case 'l':
      case 'L':
         printf("Case 'Left' selected.\n", ch);
         x--;
         break;
      case 'r':
      case 'R':
         printf("Case 'Right' selected.\n", ch);
         x++;
         break;
      default:
         printf("Invalid choice- '%c'.\n", ch);
         break;
    }

    getchar( );         /* strip trailing newline */

    printStatus(x,y);   /* Print current x,y  */

    /* Display menu of choices */
    printf("\n\n");
    printMenu( );

    ch =getchar( );
  }

  return 0;
}
```

cont…

```
void printMenu(void)
{
  printf("\tU- Increase y\n");
  printf("\tD- Decrease y\n");
  printf("\tL- Decrease x\n");
  printf("\tR- Increase x\n");

  printf("\n\tQ- to quit\n");
  printf("\n\n\tChoice: ");

  return;
}

void printStatus(int x, int y)
{
  printf("Current location: x = %d, y = %d \n", x, y);
  return;
}


/*    OUTPUT: tracker.c

          Current location: x = 0, y = 0
                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: u
          Case 'Up' selected.
          Current location: x = 0, y = 1


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: U
          Case 'Up' selected.
          Current location: x = 0, y = 2


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: r
          Case 'Right' selected.
          Current location: x = 1, y = 2
```

cont…

```
                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: r
         Case 'Right' selected.
         Current location: x = 2, y = 2


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: l
         Case 'Left' selected.
         Current location: x = 1, y = 2


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: l
         Case 'Left' selected.
         Current location: x = 0, y = 2


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: l
         Case 'Left' selected.
         Current location: x = -1, y = 2


                U- Increase y
                D- Decrease y
                L- Decrease x
                R- Increase x

                Q- to quit


                Choice: q

    */
```

Ex:

```
/*     FILE: cond_op.c     */

/* conditional operator example. */

#include <stdio.h>

int main( )
{
  int i;

  /* Loop to read integers and quit on non-integer */
  printf("Enter an integer (q to quit): ");
  while(scanf("%d", &i) == 1){  /* scanf returns # of items read. */
    printf("Value entered = %d, absolute value = %d\n",
            i, i<0?-i:i);

    printf("Enter an integer (q to quit): ");
  }

  return 0;
}


/*    OUTPUT: cond_op.c

          Enter an integer (q to quit): 7
          Value entered = 7, absolute value = 7
          Enter an integer (q to quit): -7
          Value entered = -7, absolute value = 7
          Enter an integer (q to quit): 13
          Value entered = 13, absolute value = 13
          Enter an integer (q to quit): -27
          Value entered = -27, absolute value = 27
          Enter an integer (q to quit): q

*/
```

FUNCTIONS – THE DETAILS

- C allows a block of code to be separated from the rest of the program and named.
- These blocks of code or modules are called functions.
- Functions can be passed information thru a parameter list. Any number of parameters can be passed to a function.
- Functions can pass back a result thru a return value. At most one return value can be produced.
- All the C data types are candidates for parameter types and return types.
- Ideally a function can be treated as a black-box. If you know what to pass it and what it will return; you don’t need to, or sometimes want to, know how it works.
- C has a special keyword, *void,* that is used to explicitly state that there are no parameters or no return type.
- Using a function takes place in three steps:
    - Defining the function
      The definition is the C code that completely describes the function, what it does, what formal parameters it expects, and what it’s return value and type will be.
    - Calling the function
      When the function is needed to do its work, it is “called” by its name and supplied actual parameters for the formal parameters it requires. Its return value is used if provided and needed.
    - Prototyping the function
      A prototype provides the communication information for the function, the parameter types and return value, to the compiler. This allows the compiler to more closely scrutinize your code. (This is a very, very good thing.) A prototype looks like the first line of the function definition, it identifies the parameter types and the return type of the function. A prototype should be placed within the source code at a point before the call is made. Often prototypes are placed near the top of the source code file. More often, the prototypes are placed into a .h file and *#include* is used to include them in the source code file.

Ex:

```
/*     FILE: switch3.c     */

/* A function that displays info. */

#include <stdio.h>

void print_menu(void);        /* Prototype:  - no parameters
                                             - no return value  */

int main( )
{
  int ch;

  /* Display menu of choices */
  print_menu( );
  ch =getchar( );

  /* Loop to quit on upper or lower case Q */
  while(ch != 'q' && ch != 'Q'){
    switch(ch){
      case 'a':
      case 'A':
         printf("Case 'Append' selected.\n", ch);
         break;
      case 'd':
      case 'D':
         printf("Case 'Delete' selected.\n", ch);
         break;
      case 'r':
      case 'R':
         printf("Case 'Replace' selected.\n", ch);
         break;
      default:
         printf("Invalid choice- '%c'.\n", ch);
         break;
    }

    getchar( );         /* strip trailing newline */

    /* Display menu of choices */
    printf("\n\n");
    print_menu( );

    ch =getchar( );
  }

  return 0;
}

void print_menu(void)
{
  printf("\tA- append data\n");
  printf("\tD- delete data\n");
  printf("\tR- replace data\n");

  printf("\n\tQ- to quit\n");
  printf("\n\n\tChoice: ");

  return;
}
```

cont…

```
/*    OUTPUT: switch3.c

                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: r
          Case 'Replace' selected.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: D
          Case 'Delete' selected.


                 A- append data
                 D- delete data
                 R- replace data

                 Q- to quit


                 Choice: q

*/
```

Ex:

```
/*     FILE: binary.c     */

/* A couple functions that get passed a value,
   display some output and return nothing.   */

#include <stdio.h>

void print_binary_int(unsigned int);
void print_binary_char(unsigned char);  /* Prototypes:
                                             - no return values
                                             - one parameter each  */

int main( )
{
  int first;
  char second;

  printf("Enter an integer: ");
  scanf("%d", &first);

  printf("Enter a character: ");
  scanf(" %c", &second);

  printf("Integer %d = ", first);
  print_binary_int(first);

  printf("\n\n");
  printf("Character %c = %d = ", second, second);
  print_binary_char(second);

  printf("\n\n");

  return 0;
}

void print_binary_int(unsigned int x)
{
  unsigned int divisor = 2147483648U;

  while(divisor > 0){
    if(divisor <= x){
      printf("1");
      x = x - divisor;
    }
    else
      printf("0");

    divisor = divisor/2;
  }

  return;
}
```

cont…

```
void print_binary_char(unsigned char c)
{
  unsigned char divisor = 128;

  while(divisor > 0){
    if(divisor <= c){
      printf("1");
      c = c - divisor;
    }
    else
      printf("0");

    divisor = divisor/2;
  }

  return;
}


/*    OUTPUT: binary.c

          Enter an integer: 127
          Enter a character: A
          Integer 127 = 00000000000000000000000001111111

          Character A = 65 = 01000001


*/
```

Ex:

```
/*     FILE: average.c     */

/* A function that is passed two values and returns
   one too. */

#include <stdio.h>

double average(int, int);     /*   Parameters: 2 ints
                                 Return value: a double  */

int main( )
{
  int first, second;
  double avg;

  printf("Enter first integer: ");
  scanf("%d", &first);

  printf("Enter second integer: ");
  scanf("%d", &second);

  avg = average(first, second);

  printf("Average = %f\n", avg);

  return 0;
}

double average(int x, int y)
{
  double temp;

  temp = (x + y)/2.0;

  return temp;
}


/*    OUTPUT: average.c

          Enter first integer: 1
          Enter second integer: 2
          Average = 1.500000

*/
```

Ex:

```
/*     FILE: average2.c     */

/* A function that is passed two values and returns
   one too. Function average( ) with less overhead. */

#include <stdio.h>

double average(int, int);     /*   Parameters: 2 ints
                                 Return value: a double  */

int main( )
{
  int first, second;
  double avg;

  printf("Enter first integer: ");
  scanf("%d", &first);

  printf("Enter second integer: ");
  scanf("%d", &second);

  avg = average(first, second);

  printf("Average = %f\n", avg);

  return 0;
}

double average(int x, int y)
{
  return (x + y)/2.0;
}


/*    OUTPUT: average2.c

          Enter first integer: 1
          Enter second integer: 2
          Average = 1.500000

*/
```

Ex:

```
/*     FILE: recursion.c     */

/* Recursive function to display octal. */

#include <stdio.h>
void printOctal(int x);

int main( )
{
  int value = 71;

  /* Display value in decimal */
  printf("Value = %d decimal\n", value);

  /* Display value in octal */
  printf("Value = ");
  printOctal(value);
  printf(" octal\n");

  return 0;
}

void printOctal(int x)  /* Recursive - printOctal( ) calls  */
{                       /* ... itself.                      */
  if(x < 0){
    printf("-");
    printOctal(-x);
  }
  else {
    if (x > 7)
      printOctal(x/8);
    printf("%d", x%8);
  }

  return;
}


/*    OUTPUT: recursion.c

          Value = 71 decimal
          Value = 107 octal

*/
```

Ex:
```
/*     FILE: recursion2.c     */

/* Recursive functions to display octal and hexadecimal. */

#include <stdio.h>
void printOctal(int x);
void printHex(int x);

int main( )
{
  int value = 175;

  /* Display value in decimal */
  printf("Value = %d decimal\n", value);

  /* Display value in octal */
  printf("Value = ");
  printOctal(value);
  printf(" octal\n");

  /* Display value in hexadecimal */
  printf("Value = ");
  printHex(value);
  printf(" hexadecimal\n");

  return 0;
}

void printOctal(int x)/* Recursive - printOctal( ) calls    */
{                     /* ... itself.                        */
  if(x < 0){
    printf("-");
    printOctal(-x);
  }
  else {
    if (x > 7)
      printOctal(x/8);
    printf("%d", x%8);
  }

  return;
}

void printHex(int x)/* Recursive - printHex( ) calls        */
{                     /* ... itself.                      */
  if(x < 0){
    printf("-");
    printHex(-x);
  }
  else {
    if (x > 15)
      printHex(x/16);
    if((x%16) < 10)
      printf("%d", x%16);
    else
      printf("%c", 'A' + x%16 - 10);
  }

  return;
}


/*    OUTPUT: recursion2.c

          Value = 175 decimal
          Value = 257 octal
          Value = AF hexadecimal

*/
```

POINTERS

- A pointer in C is a data type that can store the address of some other storage location.
- Pointers are used when a variable's location is of interest and not just it's value.
- A pointer is declared by using a data type followed by an asterisk, *.
- To produce the address of a variable, apply the address-of operator, & to a variable.
- Since the contents of a pointer variable are an address you need to dereference the pointer to access the value it references. That will be the value at the address the pointer contains, or the value the pointer references.

Ex:

```
/*     FILE: pointer.c     */

/* A pointer variable. */
#include <stdio.h>

int main( )
{
  int* ptr;
  int i;

  i = 7;

  ptr = &i;     /* ptr now knows where i is. */

  printf("i = %d and is at address %p\n", i, &i);

  printf("i = %d and is at address %p\n", *ptr, ptr);

  return 0;
}


/*    OUTPUT: pointer.c

          i = 7 and is at address 0022FF68
          i = 7 and is at address 0022FF68

*/
```

Ex:

```
/*     FILE: funcPt1.c     */

/* swap( ) function that fails due to pass by value. */

#include <stdio.h>
void swap(int x, int y);

int main( )
{
  int x, y;

  x = 3;
  y = 5;

  printf("Before swap, x = %d, y = %d\n", x, y);
  swap(x,y);
  printf("After swap, x = %d, y = %d\n", x, y);

  return 0;
}

void swap(int x, int y)
{
  int temp;

  printf("In swap before: %d %d\n", x, y);

  temp = x;
  x = y;
  y = temp;

  printf("In swap after: %d %d\n", x, y);

  return;
}


/*    OUTPUT: funcPt1.c

          Before swap, x = 3, y = 5
          In swap before: 3 5
          In swap after: 5 3
          After swap, x = 3, y = 5

*/
```

Ex:

```
/*     FILE: funcPt2.c     */

/* swap( ) function that works due to pointers */

#include <stdio.h>
void swap(int* x, int* y);

int main( )
{
  int x, y;

  x = 3;
  y = 5;

  printf("Before swap, x = %d, y = %d\n", x, y);
  swap(&x,&y);
  printf("After swap, x = %d, y = %d\n", x, y);

  return 0;
}

void swap(int* x, int* y)
{
  int temp;

  printf("In swap before: %d %d\n", *x, *y);

  temp = *x;
  *x = *y;
  *y = temp;

  printf("In swap after: %d %d\n", *x, *y);

  return;
}


/*    OUTPUT: funcPt2.c

          Before swap, x = 3, y = 5
          In swap before: 3 5
          In swap after: 5 3
          After swap, x = 5, y = 3

*/
```

TEXT FILE I/O

- Basic text file I/O is only slightly more difficult than the I/O done to date.
- Every I/O function seen so far has a sister function that will read/write to a file on disk.
- The programmers connection to a file on disk is a file name. The C connection to a file on disk is a file pointer, `FILE *`. The first step in doing file I/O is to translate a filename into a C file pointer using `fopen( )`.
- The file pointer is then passed to the file I/O function we are using so that C can access the appropriate file.
- Finally the connection to the file is severed by calling `fclose( )` with the file pointer as a parameter.

Ex:

```
/*     FILE: FileIO.c     */

/* Basic output using printf( ) */
#include <stdio.h>

int main( )
{
  int x = 7;
  double y =7.25;

  printf("This data will be written to the screen.\n");
  printf("x = %d, y = %f\n", x, y);

  return 0;
}


/*    OUTPUT: FileIO.c

          This data will be written to the screen.
          x = 7, y = 7.250000

*/
```

Ex:

```
/*     FILE: FileIO_2.c     */

/* Basic output to a file using fprintf( ) */
#include <stdio.h>

int main( )
{
  FILE *fptr;
  int x = 7;
  double y =7.25;

  fptr = fopen("FileIO_2.out","w");

  fprintf(fptr,"This data will be written to a file.\n");
  fprintf(fptr,"x = %d, y = %f\n", x, y);

  fclose(fptr);

  return 0;
}


/*   OUTPUT: FileIO_2.out

          This data will be written to a file.
          x = 7, y = 7.250000

*/
```

Ex:

```
/*     FILE: FileIO_3.c     */

/* Text output using fprintf( ) */
#include <stdio.h>

int main( )
{
  FILE *fptr;
  int x= 7;
  double y = 7.25;

  fptr = fopen("FileIO_3.out","w");

  if(fptr != NULL){
    fprintf(fptr,"This data will be written to a file.\n");
    fprintf(fptr,"x = %d, y = %f\n", x, y);

    fclose(fptr);
  }
  else
    printf("Unable to open file.\n");

  return 0;
}


/*   OUTPUT: FileIO_3.out

          This data will be written to a file.
          x = 7, y = 7.250000

*/
```

Ex:

```
/*     FILE: FileIO_4.c     */

/* Text I/O using fprintf( ) and fscanf( ) */
#include <stdio.h>

int main( )
{
  FILE *fptr;
  int i, x;

  fptr = fopen("FileIO_4.out","w");

  if(fptr != NULL){
    for(i=0; i<5; i++)
      fprintf(fptr,"%d\n", i);

    fclose(fptr);
  }
  else
    printf("Unable to open file.\n");

  fptr = fopen("FileIO_4.out","r");

  if(fptr != NULL){
    for(i=0; i<5; i++){
      fscanf(fptr,"%d", &x);
      printf("Read: %d\n", x);
    }

    fclose(fptr);
  }
  else
    printf("Unable to open file.\n");

  return 0;
}


/*    OUTPUT: FileIO_4.c

          Read: 0
          Read: 1
          Read: 2
          Read: 3
          Read: 4

*/


/*   OUTPUT: FileIO_4.out

          0
          1
          2
          3
          4

*/
```

BINARY FILE I/O

- Binary file I/O writes data from memory to disk in the same format as it is stored in memory.
- Generally is is not going to be human-readable but it should take up less space and can be done faster since it does not need to be translated into text.
- File pointers are used in the same manner as they are in text I/O.

Ex:
```
/*     FILE: FileIO_5.c     */

/* Binary I/O using fwrite( ) and fread( ) */
#include <stdio.h>

int main( )
{
  FILE *fptr;
  int i, x;

  x = 0;
  i = 7;

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

  fptr = fopen("tmp.dat","w");

  if(fptr != NULL){
    fwrite(&i, 4, 1, fptr);
    fclose(fptr);
  }
  else
    printf("Unable to open file for write.\n");

  fptr = fopen("tmp.dat","r");

  if(fptr != NULL){
    fread(&x, sizeof(int), 1, fptr);
    fclose(fptr);
  }
  else
    printf("Unable to open file for read.\n");

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

  return 0;
}


/*    OUTPUT: FileIO_5.c

          i = 7   x = 0
          i = 7   x = 7

*/
```

Ex:

```
/*     FILE: FileIO_6.c     */

/* Binary I/O using fwrite( ) and fread( ) */
#include <stdio.h>

int main( )
{
  FILE *fptr;
  int i, ar[5], ar2[5];

  for(i=0; i<5; i++)
    ar[i] = i*11;

  fptr = fopen("tmp.dat","w");

  if(fptr != NULL){
    fwrite(&ar[0], sizeof(int), 5, fptr);
    fclose(fptr);
  }
  else
    printf("Unable to open file for write.\n");

  fptr = fopen("tmp.dat","r");

  if(fptr != NULL){
    fread(ar2, sizeof(int), 5, fptr);
    fclose(fptr);
  }
  else
    printf("Unable to open file for read.\n");

  for(i=0; i<5; i++)
    printf("ar2[%d] = %d\n", i, ar2[i]);

  return 0;
}


/*    OUTPUT: FileIO_6.c

          ar2[0] = 0
          ar2[1] = 11
          ar2[2] = 22
          ar2[3] = 33
          ar2[4] = 44

*/
```

STRINGS

- The C definition of a string is: a set of characters terminated by a null character.
- A set of characters written inside of double quotes indicates to the compiler that it is a string.
- Placement of the null character gets handled by C itself, when C can identify that it is working with strings.
- A programmer can create and manipulate a string as a set of char locations. This set of locations can be created as an array. The programmer must then be sure that the set is used properly so that the terminating null gets placed at the end of the characters so that it represents a legitimate string.

Ex:

```
/*     FILE: string.c     */

/* Basic C string functionality */

#include <stdio.h>

int main( )
{
  char name[81];

  printf("Prompts are strings.\n");
  printf("String - %s", "Please enter a string: ");
  scanf("%s", name);

  printf("\n\nYou entered- %s\n", name);

  return 0;
}


/*    OUTPUT: string.c

          Prompts are strings.
          String - Please enter a string: Jim


          You entered- Jim

*/
```

Ex:

```
/*     FILE: string2.c     */

/* Basic C string functionality */

#include <stdio.h>

int main( )
{
  char name[81];

  name[0] = 'J';
  name[1] = 'i';
  name[2] = 'm';
  name[3] = '\0';

  printf("\n\nYou created: %s\n", name);

  return 0;
}


/*    OUTPUT: string2.c



          You created: Jim

*/
```

Ex:

```
/*     FILE: string3.c     */

/* Standard C string library routines

   Note the inclusion of string.h     */

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

int main( )
{
  char name[81];

  strcpy(name,"Jim");

  printf("You created: %s\n", name);

  return 0;
}


/*    OUTPUT: string3.c

          You created: Jim

*/
```

Ex:

```
/*     FILE: string4.c     */

/* Standard C string library routines */

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

int main( )
{
  char name[81];

  strcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: %s\n", name);

  if(strcmp(name,"jim polzin") == 0)
    printf("%s matches %s\n", name, "jim polzin");
  else
    printf("%s doesn't match %s\n", name, "jim polzin");

  if(strcmp(name,"Jim Polzin") == 0)
    printf("%s matches %s\n", name, "Jim Polzin");
  else
    printf("%s doesn't match %s\n", name, "Jim Polzin");


  printf("\n\nString length = %d\n", strlen(name));
  printf("\n\nSize of name  = %d\n", sizeof(name));

  return 0;
}


/*    OUTPUT: string4.c

          You created: Jim Polzin
          Jim Polzin doesn't match jim polzin
          Jim Polzin matches Jim Polzin


          String length = 10


          Size of name  = 81

*/
```

Ex:

```
/*     FILE: stringRead.c     */

/* Reading strings with scanf( ) */

#include <stdio.h>

int main( )
{
  char name[81];

  printf("Enter your name: ");
  scanf("%s", name);


  printf("\n\n");
  printf("You entered: %s\n", name);

  return 0;
}


/*    OUTPUT: stringRead.c

          Enter your name: Jim Polzin


          You entered: Jim

          Enter your name: One Two Three


          You entered: One

*/
```

Ex:

```
/*     FILE: stringRead2.c     */

/* Reading strings with scanf( )
   - it gets more complicated   */

#include <stdio.h>

int main( )
{
  char name[81];
  int age;

  printf("Enter your name: ");
  scanf("%s", name);

  printf("Enter your age: ");
  scanf("%d", &age);



  printf("\n\n");
  printf("Hello %s\n", name);
  printf("you are %d years old.\n", age);

  return 0;
}


/*    OUTPUT: stringRead2.c

          Enter your name: Jim Polzin
          Enter your age:


          Hello Jim
          you are 1 years old.

*/
```

Ex:

```
/*     FILE: stringRead3.c     */

/* Reading strings with scanf( )
   - the rough repair           */

#include <stdio.h>

int main( )
{
  char firstName[81];
  char lastName[81];
  int age;

  /* scanf( ) treats whitespace as a delimiter. So...
     ... you CAN read each separate piece.           */
  printf("Enter your first name: ");
  scanf("%s", firstName);

  printf("Enter your last name: ");
  scanf("%s", lastName);

  printf("Enter your age: ");
  scanf("%d", &age);



  printf("\n\n");
  printf("Hello %s %s\n", firstName, lastName);
  printf("you are %d years old.\n", age);

  return 0;
}


/*    OUTPUT: stringRead3.c

          Enter your first name: Jim
          Enter your last name: Polzin
          Enter your age: 44


          Hello Jim Polzin
          you are 44 years old.

*/
```

Ex:

```
/*     FILE: stringRead4.c     */

/* Reading strings with scanf( )
   - the real fix               */

#include <stdio.h>

int main( )
{
  char name[81];
  int age;

  printf("Enter your name: ");
  gets(name);   /* gets( ) knows all about strings
                 ... it reads all the input through
                 ... the end-of-line.               */

  printf("Enter your age: ");
  scanf("%d", &age);



  printf("\n\n");
  printf("Hello %s\n", name);
  printf("you are %d years old.\n", age);

  return 0;
}


/*    OUTPUT: stringRead4.c

          Enter your name: Jim Polzin
          Enter your age: 44


          Hello Jim Polzin
          you are 44 years old.

*/
```

ARRAYS

- C allows easy creation and access to sets of storage locations with arrays.
- An array is set of storage locations all referred to by the same name. Each individual location is uniquely identified by the array name and an index value, or offset, into the array.
- C arrays are indexed beginning with the value 0 for the index of the first location and ending with the size-1 for the index of the last location.
- Since the only difference between successive locations in an array is the index value, the computer can be used to generate the index values. This allows an entire array to be processed with very little programming effort.
- An array is homogeneous, that is all elements are of the same data type.

Ex:

```
/*     FILE: array1.c     */

/* A simple array example.
   Stores values and displays them. */

#include <stdio.h>

main( )
{
  int ar[10];
  int i;

  for(i=0; i<10; i++)
    ar[i] = 23 - i;

  for(i=0; i<10; i++)
    printf("%d\n", ar[i]);

  return 0;
}



/*    OUTPUT: array1.c

          23
          22
          21
          20
          19
          18
          17
          16
          15
          14

*/
```

Ex:

```
/*     FILE: array2.c     */

/* A simple array example.
   Stores values and displays them.

   The output is a little fancier. */

#include <stdio.h>

main( )
{
  int ar[10];
  int i;

  for(i=0; i<10; i++)
    ar[i] = 23 - i;

  for(i=0; i<10; i++)
    printf("ar[%d] = %d\n", i, ar[i]);

  return 0;
}



/*    OUTPUT: array2.c

          ar[0] = 23
          ar[1] = 22
          ar[2] = 21
          ar[3] = 20
          ar[4] = 19
          ar[5] = 18
          ar[6] = 17
          ar[7] = 16
          ar[8] = 15
          ar[9] = 14

*/
```

Ex:

```
/*     FILE: array3.c     */

/* Reads values and displays them. */

#include <stdio.h>

main( )
{
  int ar[10];
  int i;

  for(i=0; i<10; i++)
  {
    printf("Enter value %d of %d: ", i+1, 10);
    scanf("%d", &ar[i]);
  }

  for(i=0; i<10; i++)
    printf("%d\n", ar[i]);

  return 0;
}



/*    OUTPUT: array3.c

          Enter value 1 of 10: 1
          Enter value 2 of 10: 2
          Enter value 3 of 10: 3
          Enter value 4 of 10: 4
          Enter value 5 of 10: 5
          Enter value 6 of 10: 6
          Enter value 7 of 10: 7
          Enter value 8 of 10: 8
          Enter value 9 of 10: 9
          Enter value 10 of 10: 10
          1
          2
          3
          4
          5
          6
          7
          8
          9
          10

*/
```

Ex:

```
/*     FILE: array4.c     */

/* Reads in values, computes their average, and displays them. */

#include <stdio.h>

main( )
{
  int ar[10];
  int i, sum;
  double avg;

  for(i=0; i<10; i++)
  {
    printf("Enter value %d of %d: ", i+1, 10);
    scanf("%d", &ar[i]);
  }

  sum = 0;
  for(i=0; i<10; i++)
    sum = sum + ar[i];

  avg = (double)sum / 10;
  printf("avg = %f\n", avg);

  return 0;
}



/*    OUTPUT: array4.c

          Enter value 1 of 10: 4
          Enter value 2 of 10: 4
          Enter value 3 of 10: 4
          Enter value 4 of 10: 4
          Enter value 5 of 10: 4
          Enter value 6 of 10: 5
          Enter value 7 of 10: 5
          Enter value 8 of 10: 5
          Enter value 9 of 10: 5
          Enter value 10 of 10: 5
          avg = 4.500000

*/
```

Ex:

```
/*     FILE: array5.c     */

/* Reads in values, computes their average, and displays them.

   Uses a defined constant to simplify future changes and
   increase readability. */

#include <stdio.h>
#define SIZE 10

main( )
{
  int ar[SIZE];
  int i, sum;
  double avg;

  for(i=0; i<SIZE; i++)
  {
    printf("Enter value %d of %d: ", i+1, SIZE);
    scanf("%d", &ar[i]);
  }

  sum = 0;
  for(i=0; i<SIZE; i++)
    sum = sum + ar[i];

  avg = (double)sum / SIZE;
  printf("avg = %f\n", avg);

  return 0;
}



/*    OUTPUT: array5.c

          Enter value 1 of 10: 4
          Enter value 2 of 10: 4
          Enter value 3 of 10: 4
          Enter value 4 of 10: 4
          Enter value 5 of 10: 4
          Enter value 6 of 10: 5
          Enter value 7 of 10: 5
          Enter value 8 of 10: 5
          Enter value 9 of 10: 5
          Enter value 10 of 10: 5
          avg = 4.500000

*/
```

Ex:

```
/*     FILE: max_cnt.c     */

/*
   Loads an array with up to SIZE values.
   Finds the max and the count of values
   greater than 90.
*/

#include <stdio.h>
#define SIZE 50

int main( )
{
  int scores[SIZE];
  int i, n, max, a_count;

  /* Get number of values to read */
  printf("Please enter number of scores (%d or less): ", SIZE);
  scanf("%d", &n);

  /* Validate number entered by user. */
  if (n<=SIZE && n>0){
    /* Read score values into array */
    for(i=0; i<n; i++)
    {
      printf("Enter value %d of %d: ", i+1, n);
      scanf("%d", &scores[i]);
    }

    /* Find maximum of values read. */
    max = scores[0];
    for(i=1; i<n; i++)
    {
      if (scores[i] > max)
        max = scores[i];
    }

    printf("Max score = %d\n", max);

    /* Count number of A's, scores greater than 90 */
    a_count = 0;
    for(i=0; i<n; i++)
    {
      if (scores[i] > 90)
        a_count++;
    }

    printf("A's = %d\n", a_count);
  }

  return 0;

}


/*    OUTPUT: max_cnt.c

          Please enter number of scores (50 or less): 4
          Enter value 1 of 4: 75
          Enter value 2 of 4: 85
          Enter value 3 of 4: 95
          Enter value 4 of 4: 92
          Max score = 95
          A's = 2

*/
```

Ex:

```
/*     FILE: sort1.c     */

/* An example of sorting with selection sort. */

#include <stdio.h>
#define SIZE 10
main( )
{
  int ar[SIZE];
  int pass,item,position,temp;

  for(item=0; item<SIZE; item++)  /* load array with values */
     ar[item] = item*10;

  printf("\nOriginal array:\n");
  for(item=0; item<SIZE; item++)  /* display values in array */
     printf("ar[%d] = %d\n", item, ar[item]);

    /* Selection-sort the values read in. */
    for(pass=0; pass<SIZE-1; pass++){
      position = pass;
      for(item=pass+1; item<SIZE; item++)
        if (ar[position] < ar[item])
          position = item;
      if(pass != position){
        temp = ar[pass];
        ar[pass] = ar[position];
        ar[position] = temp;
      }
    }

  printf("\nSorted array:\n");
  for(item=0; item<SIZE; item++)  /* display values in array */
     printf("ar[%d] = %d\n", item, ar[item]);

  return 0;
}


/*    OUTPUT: sort1.c


          Original array:
          ar[0] = 0
          ar[1] = 10
          ar[2] = 20
          ar[3] = 30
          ar[4] = 40
          ar[5] = 50
          ar[6] = 60
          ar[7] = 70
          ar[8] = 80
          ar[9] = 90

          Sorted array:
          ar[0] = 90
          ar[1] = 80
          ar[2] = 70
          ar[3] = 60
          ar[4] = 50
          ar[5] = 40
          ar[6] = 30
          ar[7] = 20
          ar[8] = 10
          ar[9] = 0

*/
```

Ex:

```
/*     FILE: select.c     */

/* Loads an array with up to 50 values.
   Sorts the values into descending order. */

#include <stdio.h>
#define SIZE 50

int main( )
{
  int scores[SIZE];
  int i, n, pass, item, position, temp;

  /* Get number of values to read */
  printf("Please enter number of scores (%d or less): ", SIZE);
  scanf("%d", &n);

  /* Validate number entered by user. */
  if (n<=SIZE && n>0){
    /* Read score values into array */
    for(i=0; i<n; i++)
    {
      printf("Enter value %d of %d: ", i+1, n);
      scanf("%d", &scores[i]);
    }

    /* Selection-sort the values read in. */
    for(pass=0; pass<n-1; pass++){
      position = pass;
      for(item=pass+1; item<n; item++)
        if (scores[position] < scores[item])
          position = item;
      if(pass != position){
        temp = scores[pass];
        scores[pass] = scores[position];
        scores[position] = temp;
      }
    }

    /* Display scores in sorted order */
    printf("\n\nThe scores in order.\n");
    for(i=0; i<n; i++)
      printf("%d- %d\n", i+1, scores[i]);
  }

  return 0;
}

/*    OUTPUT: select.c

          Please enter number of scores (50 or less): 6
          Enter value 1 of 6: 75
          Enter value 2 of 6: 42
          Enter value 3 of 6: 88
          Enter value 4 of 6: 37
          Enter value 5 of 6: 99
          Enter value 6 of 6: 92


          The scores in order.
          1- 99
          2- 92
          3- 88
          4- 75
          5- 42
          6- 37
*/
```

Ex:
```
/*     FILE: arrayString.c     */

/* Strings are arrays */

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

int main( )
{
  char name[81];

  strcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: %s\n", name);

  name[6] = 'L';

  printf("It was changed to: %s\n", name);

  return 0;
}


/*    OUTPUT: arrayString.c

          You created: Jim Polzin
          It was changed to: Jim PoLzin

*/
```

Ex:

```
/*     FILE: arrayString2.c     */

/* Strings are arrays */

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

int main( )
{
  int i;
  char name[81];

  strcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: ");

  for(i=0; name[i] != '\0'; i++)
    putchar(name[i]);

  putchar('\n');

  return 0;
}


/*    OUTPUT: arrayString2.c

          You created: Jim Polzin

*/
```

Ex:
```
/*     FILE: arrayString3.c     */

/* Strings as parameters */

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

void myPuts(char [ ]);
void myStrcpy(char [ ], char[ ]);

int main( )
{
  int i;
  char name[81];

  myStrcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: ");

  myPuts(name);

  return 0;
}

void myPuts(char s[ ])
{
  int i;

  for(i=0; s[i] != '\0'; i++)
    putchar(s[i]);

  putchar('\n');

  return;
}

void myStrcpy(char dest[ ], char src[ ])
{
  int i;

  for(i=0; src[i] != '\0'; i++)
    dest[i] = src[i];

  dest[i] = '\0';

  return;
}


/*    OUTPUT: arrayString3.c

          You created: Jim Polzin

*/
```

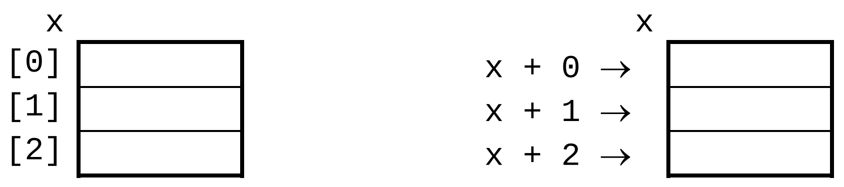
Ex:

```
/*     FILE: arrayString4.c     */

/* Strings as parameters

   myStrcpy - altered       */

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

void myPuts(char [ ]);
void myStrcpy(char [ ], char[ ]);

int main( )
{
  int i;
  char name[81];

  myStrcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: ");

  myPuts(name);

  return 0;
}

void myPuts(char s[ ])
{
  int i;

  for(i=0; s[i] != '\0'; i++)
    putchar(s[i]);

  putchar('\n');

  return;
}

void myStrcpy(char dest[ ], char src[ ])  /* C style, streamlined! */
{
  int i;

  for(i=0; (dest[i]=src[i]) != '\0'; i++)
  ;

  return;
}


/*    OUTPUT: arrayString4.c

          You created: Jim Polzin

*/
```

ARRAYS AND POINTERS

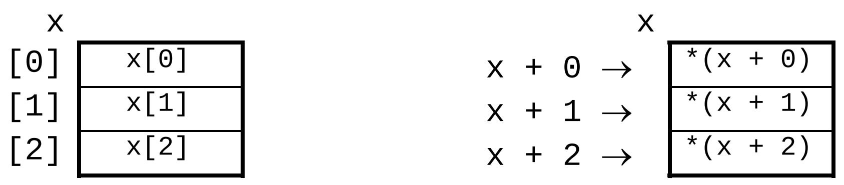
- With a 1-D array the array name is the address of the first thing in the array.

```
int  x[3];
```



`x` - address of the first thing in the integer array
`x + 1`- address of the second thing in the integer array
`x + 2`- address of the third thing in the integer array

- With a 1-D array dereferencing once, or indexing into the array once using the array access operator, gives a value in the array.



`*x == x[0]`
- value of the first element in the array

`*(x + 1)== x[1]`
- value of the second element in the array

`*(x + 2)== x[2]`
- value of the third element in the array

Ex:
```
/*     FILE: pointer2.c     */

/* Array names are addresses. */
#include <stdio.h>

int main( )
{
  int* ptr;
  int i;
  int ar[5];

  for (i=0; i<5; i++)
    ar[i] = i+1;

  ptr = ar;     /* ptr now knows where ar is. */

  printf("ar[0] = %d and is at address %p\n", ar[0], ar);

  printf("*ptr = %d and is at address %p\n\n", *ptr, ptr);

  for (i=0; i<5; i++)
    printf("ar[%d] = %d and is at address %p\n", i, ar[i], ar+i);

  printf("\n");
  for (i=0; i<5; i++)
    printf("*(ptr+i) = %d and is at address %p\n", *(ptr+i), ptr+i);

  return 0;
}


/*    OUTPUT: pointer2.c

          ar[0] = 1 and is at address 0022FF38
          *ptr = 1 and is at address 0022FF38

          ar[0] = 1 and is at address 0022FF38
          ar[1] = 2 and is at address 0022FF3C
          ar[2] = 3 and is at address 0022FF40
          ar[3] = 4 and is at address 0022FF44
          ar[4] = 5 and is at address 0022FF48

          *(ptr+i) = 1 and is at address 0022FF38
          *(ptr+i) = 2 and is at address 0022FF3C
          *(ptr+i) = 3 and is at address 0022FF40
          *(ptr+i) = 4 and is at address 0022FF44
          *(ptr+i) = 5 and is at address 0022FF48

*/
```

Ex:
```
/*     FILE: array6.c     */

/* Passing an array to a function.
   Array name/pointer equivalence.*/

#include <stdio.h>
#define SIZE 5
void print_array(int a[ ], int length);
void print_array2(int* a, int length);

main( )
{
  int ar[SIZE];
  int i;

  for(i=0; i<SIZE; i++)
  {
    printf("Enter value %d of %d: ", i+1, SIZE);
    scanf("%d", ar + i);
  }

  printf("\n");
  print_array(ar, SIZE);

  printf("\n");
  print_array2(ar, SIZE);

  return 0;
}

void print_array(int a[ ], int length)
{
  int i;
  for(i=0; i<length; i++)
    printf("a[%d] = %d\n", i, a[i]);

  return;
}

void print_array2(int* a, int length)
{
  int i;
  for(i=0; i<length; i++)
    printf("a[%d] = %d\n", i, a[i]);

  return;
}

/*    OUTPUT: array6.c

          Enter value 1 of 5: 11
          Enter value 2 of 5: 22
          Enter value 3 of 5: 33
          Enter value 4 of 5: 44
          Enter value 5 of 5: 55

          a[0] = 11
          a[1] = 22
          a[2] = 33
          a[3] = 44
          a[4] = 55

          a[0] = 11
          a[1] = 22
          a[2] = 33
          a[3] = 44
          a[4] = 55
*/
```

Ex:
```
/*     FILE: string5.c     */

/* Passing a string to a function - pointer */
#include <stdio.h>
#include <string.h>

void myPuts(char *str);

int main( )
{
  char name[81];

  strcpy(name,"Jim");
  strcat(name," Polzin");

  printf("You created: %s\n", name);
/* Another way */
  myPuts("You created: ");
  myPuts(name);
  myPuts("\n");

  return 0;
}

void myPuts(char *str)
{
  while(*str != '\0')
    putchar(*str++);

  return;
}


/*    OUTPUT: string5.c

          You created: Jim Polzin
          You created: Jim Polzin

*/
```

Ex:

```
/*     FILE: string6.c     */

/* Passing a string to a function - pointers */
#include <stdio.h>
#include <string.h>

void myPuts(char *str);
void myStrcpy(char *dest, char *src);
char * myStrcpy2(char *dest, char *src);

int main( )
{
  char name[81];

  myStrcpy(name,"Jim Polzin");

  myPuts("You created: ");
  myPuts(name);
  myPuts("\n");

  myPuts("You created: ");
  myPuts(myStrcpy2(name,"C Programming Language."));
  myPuts("\n");

  return 0;
}

void myPuts(char *str)
{
  while(*str)
    putchar(*str++);

  return;
}

void myStrcpy(char *dest, char *src)
{
  while(*src != '\0'){
    *dest = *src;
    dest++;
    src++;
  }
  *dest = *src;

  return;
}

char * myStrcpy2(char *dest, char *src)
{
  char * ret = src;

  while(*dest++ = *src++);

  return ret;
}


/*    OUTPUT: string6.c

          You created: Jim Polzin
          You created: C Programming Language.

*/
```

INDEX