Deceptively Simple Big Idea

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Big Idea for Code: Functions

One idea ⇒One definition, many uses

One idea → • Identify a "sub-problem" that has to be solved in your program

Many Name → • Choose a name to represent "*the solution of that problem by code*"

One definition → • Write that solution code (only once)

Many Uses → • Whenever you see that same sub-problem again, use the function name to say "*go to that code now to take care of this problem, and don't come back until you're done*"

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Some C Functions

We have already seen and used several functions:

```
int main (void)
{
      return 0;
}
```

← **Function definition for main( )**

```
printf ("control", list);

scanf ("control", &list);
```

← **Calls to the functions printf( ) and scanf( )**

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Library functions

- Pre-written functions are commonly packaged in "libraries"
- Every standard C compiler comes with a set of standard libraries
- Remember #include <stdio.h> ?
  - Tells the compiler you intend to use the "standard I/O library" functions
  - printf and scanf are in the standard I/O library
  - So are lots of other I/O related functions
- There are (many) other useful functions in other libraries

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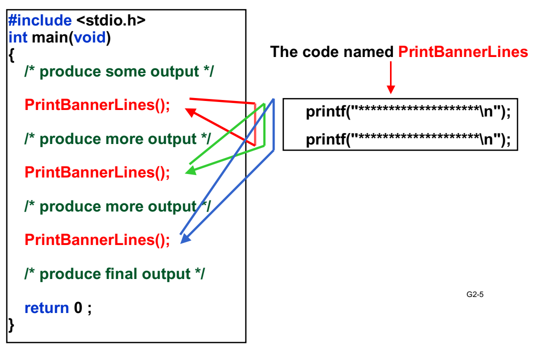

```
#include <stdio.h>
int main(void)
{
   /* produce some output */

   PrintBannerLines();

   /* produce more output */

   PrintBannerLines();

   /* produce more output */

   PrintBannerLines();

   /* produce final output */

   return 0 ;
}
```

The code named PrintBannerLines

```
printf("**********************\n");
printf("**********************\n");
```

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Syntax for PrintBannerLines

```
/* write separator line on output */
void PrintBannerLines (void)
{
   printf("****************\n");
   printf("****************\n");
}
```

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Two Key Features

1. The name of the function and
2. the function body: code that is to be executed when the function is called.

function name

```
/* write separator line on output*/
void PrintBannerLines (void)
{
    printf("****************\n");
    printf("****************\n");
}
```

heading comment

function body (statements to be executed).

A function can have ANY number of ANY kind of statements.

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Further details: *void*

The keyword void has two different roles in this function definition.

indicates that the function does not return a value.

```
/* write separator line on output*/
void PrintBannerLines (void)
{
    printf("****************\n");
    printf("****************\n");
}
```

indicates that the function has no parameters.

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Using *PrintBannerLines*

```
#include <stdio.h>
void PrintBannerLines (void)
{
    printf("****************\n");
    printf("****************\n");
}
int main (void)
{
    /* produce some output */
    ...
    PrintBannerLines( );
    ...
    return 0;
}
```

The definition of the function must precede all calls to it in the file.

Empty ( ) is required when a parameter-less (void) function is called.

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Providing an Input to the Function: Parameters

Can we modify the function so that instead of

print two rows of asterisks
(callee decides)

it will:

print N rows of asterisks
(caller decides)

where N is the number of rows that we want "this time" when we call it

N is information that the function needs to know

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```
#include <stdio.h>
int main(void)
{
    PrintBannerLines(5);

    /* produce some output */

    PrintBannerLines(2);

    /* produce final output */

    PrintBannerLines(5);

    return 0;
}
```

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Code for PrintBannerLines

The value in the parentheses is called the "parameter" of this call.

Code for the Modified Function

The function will start off this way:

```
void PrintBannerLines (int n)
{
    ...
```

n is the "parameter" of the function. n can be used inside the function just like a variable

(The full solution won't be shown now. It requires a feature called "iteration" that we will cover later. We'll see parameters in other examples.)

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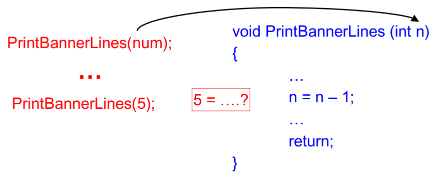
Parameters are New Variables!!!



```
PrintBannerLines(num);          void PrintBannerLines (int n)
                                {
        ...                          …
PrintBannerLines(5);   5 = ….?       n = n – 1;
                                     …
                                     return;
                                }
```

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Some Terminology Confusion

Many people use the term *formal parameter* instead of *parameter* and *actual parameter* instead of *argument*. We will try to stick to *parameter* and *argument* for simplicity, but the other terminology will probably slip in from time to time.

People often refer to replacing a parameter with the argument in a function call as “passing the argument to the function”.

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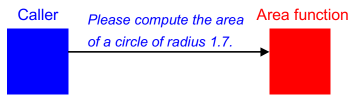
Passing Results Back to the Caller

Specification: Write a function that, given the radius, computes the area of a circle with that radius.

What should it do with the result?



newArea = Area(1.7);

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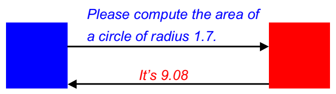
Returned Values

Parameters are a way for the calling routine to “send data” to the function

The new concept, return values, are the opposite, a way for the function to send data back to the calling routine



newArea = Area(1.7);   return 3.14 * r * r;

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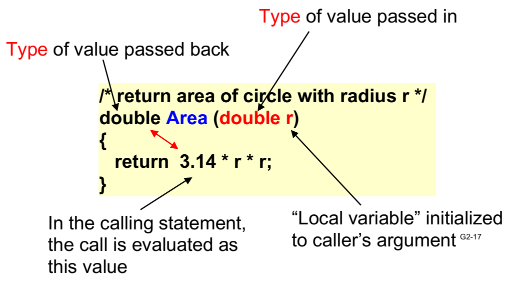
Returned values



Type of value passed in

Type of value passed back

```
/* return area of circle with radius r */
double Area (double r)
{
   return 3.14 * r * r;
}
```

In the calling statement, the call is evaluated as this value

“Local variable” initialized to caller’s argument

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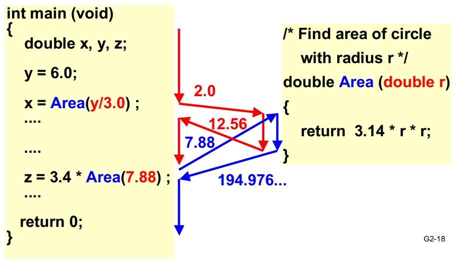
Control and Data Flow



```
int main (void)
{
   double x, y, z;
   y = 6.0;
   x = Area(y/3.0) ;
   ....
   ....
   z = 3.4 * Area(7.88) ;
   ....
  return 0;
}
```

```
/* Find area of circle
   with radius r */
double Area (double r)
{
   return 3.14 * r * r;
}
```

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More on *return*

For *void* functions:
  return; causes control flow to return to the statement following the call in the caller

For functions that return a value:
  return *expression;* causes control flow to return to the caller. The function call is "replaced" with the returned value.

totalArea = Area(1.7) + Area(3.4);

Note: no parentheses are needed around the expression
Return is a C statement. It is not a function call

Discussion Questions

1. Can you have more than one ***return*** inside a function?
2. Does a ***return*** statement have to be the last statement of a function?
3. If a function starts off as
   double calculation (void) {...
   could it contain this statement?
   return;
4. If a function starts off as
   void printfBankBalance (void) {...
   could it contain this statement?
   return currentBalance;

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Matching Up Types

The actual arguments must be of the type of the parameter.

The returned value will be of the type given before the function's name.

The "usual" conversion rules apply (as in expressions).

```
int main (void)
{ ...
  z = 98.76;
  x = 34.575 * area ( z/2.0 );
  ...
  return 0;
}
```

```
/* Find area of circle  with radius r */
double area (double r)
{
  return   3.14 * r * r;
}
```

Multiple Parameters

A function may have more than one parameter

Arguments must match parameters in number, order, and type

```
double gpt, gpa;
gpt = 3.0 + 3.3 + 3.9;
gpa = Avg ( gpt, 3 );
...
```

```
double Avg (double total, int count)
{
  return  total  /  (double) count ;
}
```

arguments **parameters**

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Local Variables

A function can define its own local variables.

The locals have meaning only within the function.
Local variables are created when the function is called.
Local variables cease to exist when the function returns.

Parameters are also local.

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A Function with Local Variables

```
/* return area of circle with
   radius r */
double CircleArea (double r)     ← parameter
{
   double rsquared, area;        ← local variables
   rsquared = r * r ;
   area = 3.14 * rsquared ;
   return   area;
}
```

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LOCAL Variables

```
/* return area of circle with radius r */

double CircleArea (double r)
{
   double rsquared, area;
   rsquared = r * r ;
   area = 3.14 * rsquared ;
   return   area;
}
```

```
int  main (void)
{
     double result;
     result = CircleArea(8.0);
     rsquared = 2.0;
     result = CircleArea(2.0);
}
```

Scope Error

(undeclared identifier)

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Another Scope Error

```
int  main (void)
{
     double result;
     result = CircleArea(8.0);
}
```

Scope Error

(undeclared identifier)

```
/* return area of circle with radius r */

double CircleArea (double r)
{
   double rsquared, area;
   rsquared = r * r ;
   area = 3.14 * rsquared ;
   return   area;
}
```

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Scope

Function names are defined everywhere ("globally") within the file starting at the point they are declared.

Variables are local to the function in which they are declared.

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Global Variables

C lets you define variables that are not inside any function.

They have global scope.

Global variables have a few legitimate uses, but they often are:

- a crutch to avoid using parameters
- poor style

```
int  myGlobal;
```

```
/* return area of circle with radius r */

void CircleArea (double r)
{
   double rsquared;
   rsquared = r * r ;
   myGlobal = 3.14 * rsquared ;
}
```

```
int  main (void)
{
     double result;
     CircleArea(8.0);
     result =myGlobal;
}
```

Surgeon General's Warning

In this course:

global variables are completely verboten! Only *local* variables are allowed in homework programs

Exception: *symbolic constants* may be global

Their use is encouraged!

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Local Variables: Summary

(Formal) parameters and variables declared in a function are local to it:

cannot be accessed (used) by other functions except by being passed as actual parameters or return values)

Allocated (created) on function entry, de-allocated (destroyed) on function return.

(Formal) parameters initialized by copying value of argument (actual parameter). ("Call-by-value")

A good idea? YES!

localize information; reduce interactions.

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Functions: Summary

Functions may take several parameters, or none.

Functions may return one value, or none.

Functions are valuable!

- A tool for program structuring.
- Provide *abstract* services: the caller cares what the functions do, but not how.
- Make programs easier to write, debug, and understand.

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Looking Ahead

There is still more to learn about functions

- We'll study other methods of parameter passing
- We'll also look at functions as a fundamental design technique

Many students report that functions are the first really difficult concept of the course.   They have to be mastered. You haven't seen the last of functions, and you never will!

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