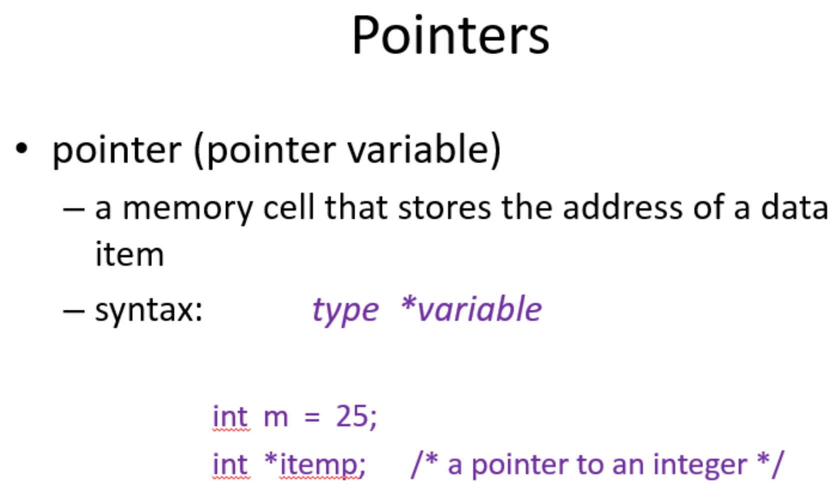
Engr 101 **Sept. 16, 2019**
Day 10

A pointer is a new variable type which holds the *address* of another variable.

Pointers are declared using the * operator.



Pointers

- pointer (pointer variable)
  - a memory cell that stores the address of a data item
  - syntax: *type *variable*

```
int m = 25;
int *itemp;     /* a pointer to an integer */
```

In this example itemp is a pointer variable.

We can make itemp hold the address of the variable *m* like this:
`itemp = &m;`

Recall that **&** is the address operator that we used in `scanf`

```
#include<stdio.h>
int main()
{
      int m = 25;
      int *mPointer;
      mPointer = &m;
      printf("m = %d\n", m);
      printf("&m = %d\n", &m);
      printf("mPointer = %d\n", mPointer);
}
```

This program prints the following:

```
m = 25
&m = 19922488
mPointer = 19922488
Press any key to continue . . .
```

Notice that the *address* of *m* is stored in *mPointer*.

If you run this program again or on another computer the address of *m* may be at a different location – it depends on where the compiler places it in memory.

We can access the data stored in variable *m* by using its name as in:
printf("%d\n", m);

or,

we can access the data *indirectly* by using the variables address stored in *mPointer*. To do this we again use the * operator as in:

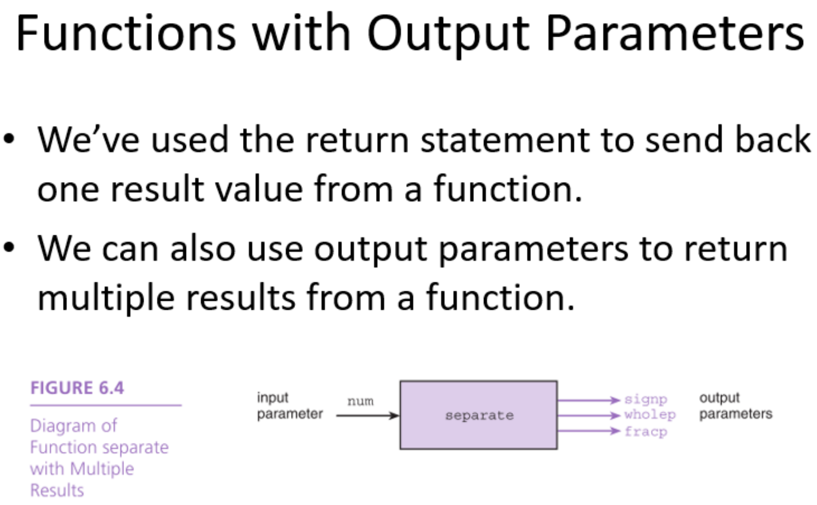
```
printf("%d\n", *mPointer);
```

An indirect address is the address of an address of the data. When we use *mPointer as a variable we effectively go to the mPointer location, get the address, and go to that address to find the data.

This is somewhat confusing. Note that we now have three different meanings for the * operator and which meaning is used by the compiler depends on the context – that is, how it is used.

1. If we write `z = x * y;` the * operator means multiplication
2. If we write `int *x;` the * operator is used to declare x to be a pointer to an int variable.
3. If we use `y = *x;` the * operator is used for indirect address. We go to the location *x* and find the information there which is the address of the data which gets moved into y.

There are numerous uses for pointers but the most common is to create output parameters for a function.



Functions with Output Parameters

- We've used the return statement to send back one result value from a function.
- We can also use output parameters to return multiple results from a function.

FIGURE 6.4

Diagram of Function separate with Multiple Results

For example, suppose we want to write a function which will swap two variables which are ints. If we name the function *Swap* and pass it two integers as arguments as in:

```
int x = 5, y = 9;
Swap(x, y);
```

The function will fail because *x* and *y* are passed by value.

```
int main()
   {int x = 5, y = 9;
    Swap(x, y);
    printf("%d %d\n", x, y);
    return 0;
   }
int Swap(int x, int y)
  {int tmp;
   tmp = x;
   x = y;
   y = tmp;
  }
```

Swap	**main**	**memory**
	x	5
	y	9
x		~~5~~ 9
y		~~9~~ 5
tmp		5

We can fix this program by passing the address of x and y using pointers.

```
void Swap(int *xPtr, int *yPtr);
int main()
   {int x = 5, y = 9;
    Swap(&x, &y);
    printf("%d %d\n", x, y);
    return 0;
   }
void Swap(int *xPtr, int *yPtr)
  {int tmp;
   tmp = *xPtr;
   *xPtr = *yPtr;
   *yPtr = tmp;
  }
```

Swap	**main**	**memory**
*xPtr	x	~~5~~ 9
*yPtr	y	~~9~~ 5
tmp		5

Syntax for writing functions with output parameters

Prototype:

```
int MyFunction(int x, int *y);
//x is passed by value, y is passed by reference
```

Calling statement:

```
int z;
z = MyFunction(x, &y);
//For reference parameters you must pass the address
```

Function definition

```
int MyFunction(int x, int *y)
{
    int z;
    x = 2;
    *y = 3;
      //Reference parameter is used with dereferencing operator
    z = x + *y;
    return z;
}
```

Example

Write a function which will prompt the user for two doubles and return these to the main program.

In the main program:

```
double a, b;
Getab(&a, &b);
```

In the function

```
void Getab(double *a, double *b)
{
    double x, y;
    printf("Enter a value for a... ");
    scanf_s("%lf", &x);
    *a = x;
    printf("Enter a value for b... ");
    scanf_s("%lf", &y);
    *b = y;
}
```

```
void Getab(double *a, double *b)
{
    printf("Enter a value for a... ");
    scanf_s("%lf", &*a);
    printf("Enter a value for b... ");
    scanf_s("%lf", &*b);
}
```

Memory map example

Complete the memory map for the following program.

```
#include<stdio.h>
void Fun1(int a, int *b);
void Fun2(int a, int *b);
int main()
{
       int x = 5, y = 2;
       printf("%d, %d\n", x, y);
       Fun1(x, &y);
       printf("%d, %d\n", x, y);
}
void Fun1(int a, int *b)
{
       int c;
       printf("%d, %d\n", a, *b);
       c = *b;
       Fun2(c, &a);
       printf("%d, %d, %d\n", a, *b, c);
}
void Fun2(int a, int *b)
{
       int c;
       printf("%d, %d\n", a, *b);
       c = *b;
       printf("%d, %d, %d\n", a, *b, c);
}
```

Fun2	Fun1	Main	Data

Printed Output

Memory map example SOLUTION

Complete the memory map for the following program.

```
#include<stdio.h>
void Fun1(int a, int *b);
void Fun2(int a, int *b);
int main()
{
       int x = 5, y = 2;
       printf("%d, %d\n", x, y);
       Fun1(x, &y);
       printf("%d, %d\n", x, y);
}
void Fun1(int a, int *b)
{
       int c;
       printf("%d, %d\n", a, *b);
       c = *b;
       Fun2(c, &a);
       printf("%d, %d, %d\n", a, *b, c);
}
void Fun2(int a, int *b)
{
       int c;
       printf("%d, %d\n", a, *b);
       c = *b;
       printf("%d, %d, %d\n", a, *b, c);
}
```

Fun2	Fun1	Main	Data
		x	5
	*b	y	2
*b	a		5
	c		2
a			2
c			5

Printed Output
5, 2
5, 2
2, 5
2, 5, 5
5, 2, 2
5. 2

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Pointers and output parameters

Polar coordinates are written in the form of $r\angle\theta$ and rectangular coordinates are expressed as the pair *(x, y)*. Write a program that prompts the user to enter *r* and θ (in degrees) and calls a function named *ConvertToXY* which converts the polar coordinates to Cartesian coordinates and returns them to the main program for printing. You will need to pass your function *r* and *theta* by value and *x* and *y* by reference.

To convert polar to Cartesian use:

$x = r\cos(theta)$

$y = r\sin(theta)$

$\pi = 3.141592653589793$

Turn in a printed copy of your source file.

SOLUTION

```c
#include<stdio.h>
#include<math.h>
#define PI 3.141592653589793
void ConvertXY(double r, double theta, double *x, double *y);
int main()
{
	double r, theta, x, y;
	printf("Enter a value for r... ");
	scanf_s("%lf", &r);
	printf("Enter theta in degrees... ");
	scanf_s("%lf", &theta);
	ConvertXY(r, theta, &x, &y);
	printf("%6.3f angle %6.3f = (%6.3f, %6.3f)\n", r, theta, x, y);
}
void ConvertXY(double r,double theta,double *x,double *y)
{
	*x = r*sin(theta*PI/180);
	*y = r*cos(theta*PI/180);
}
```