CS101 Introduction to computing

Function

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Outline

- **Function**
- Calling, Definition
- Parameter Passing
- Local Variable
- Scope Rules

Functions

- Modularize a program
- All variables declared inside functions are local variables : Known only in function defined
- Parameters: Communicate info. between functions
- Function Benefits
  - Divide and conquer : Manageable program development
  - Software reusability : Use existing functions as building blocks for new programs and
  - Abstraction : hide internal details (library functions)
  - Avoids code repetition

Functions

- A C program is made up of one or more functions, one of which is main( ).
- Execution always begins with main( )
  - No matter where it is placed in the program.
- main( ) is located before all other functions.
- When program control encounters a function name, the function is **called** (**invoked**).
  1. Program control passes to the function.
  2. The function is executed.
  3. Control is passed back to the calling function.

Sample Function Call

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

  printf("Hello World!\n");
  return 0 ;
}
```

printf is the name of a **predefined function** in the stdio library

this statement is is known as a **function call**

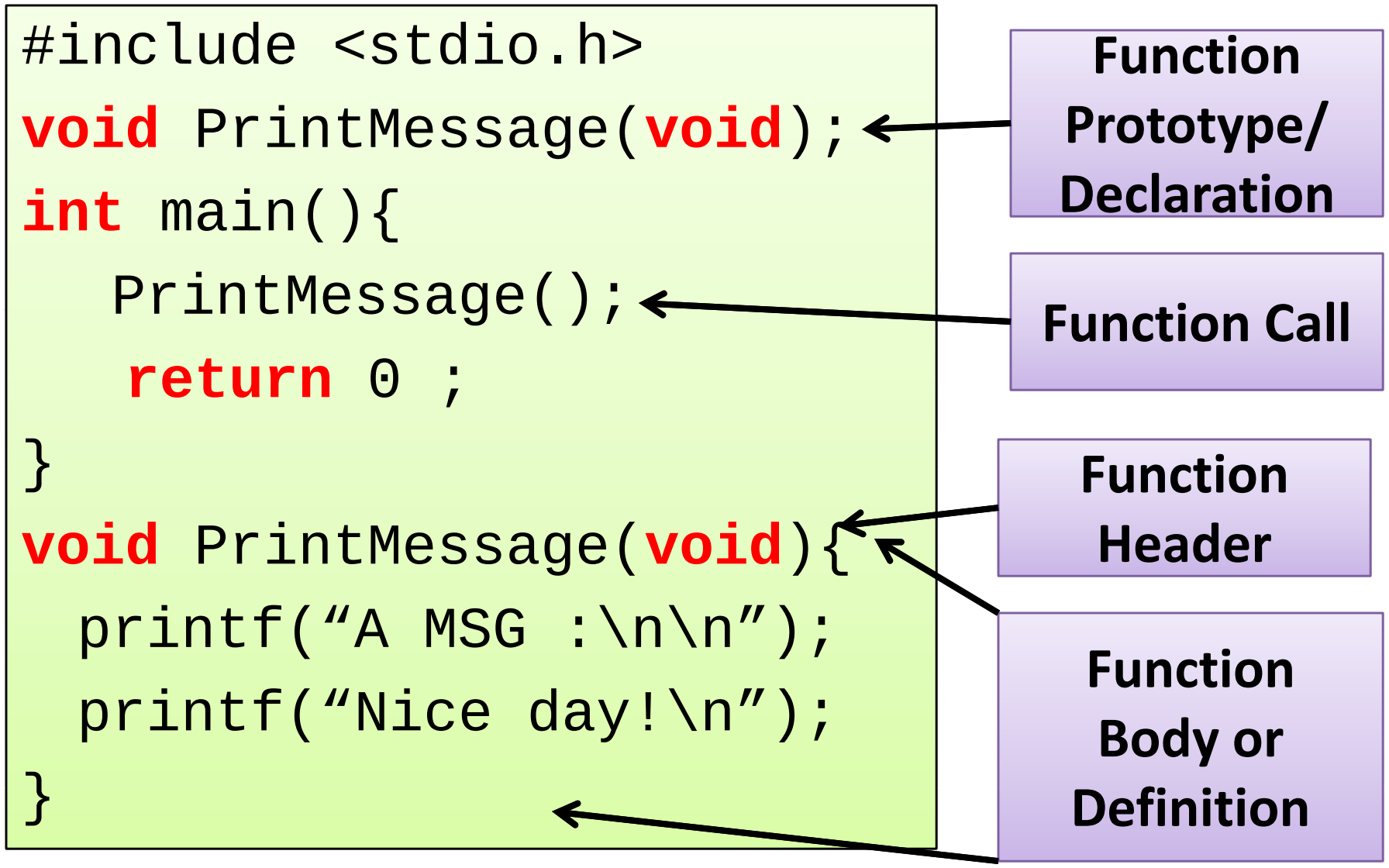
this is a string we are **passing** as an **argument** (**parameter**) to the printf function

Functions (con't)

- We have used three predefined functions so far:
  - –printf, scanf, pow, sqrt, abs, sin, cos
- Programmers can write their own functions.
- Typically, each module in a program's design hierarchy chart is implemented as a function.

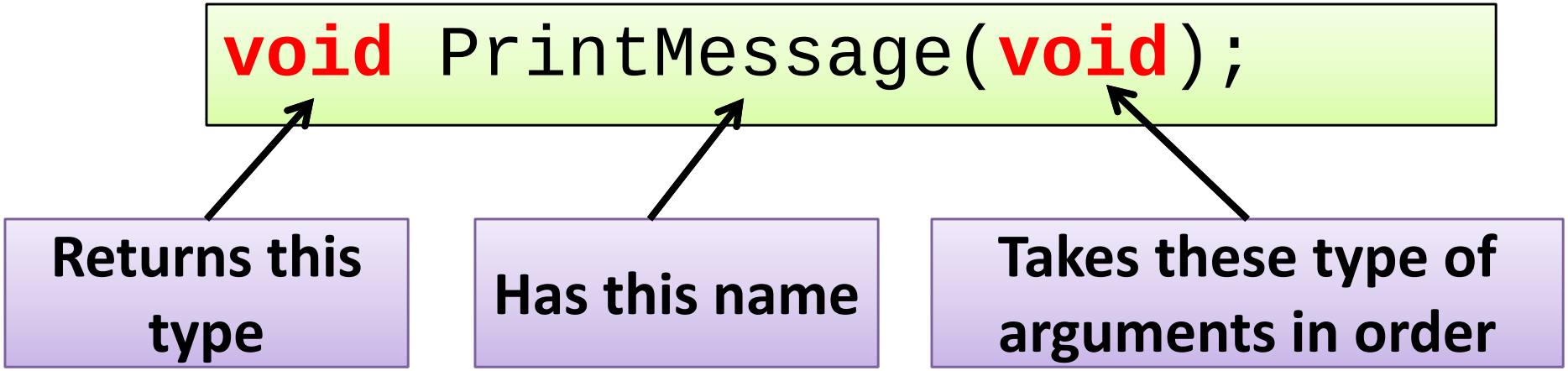
Sample -Defined Function

```
#include <stdio.h>
void PrintMessage(void);
int main(){
   PrintMessage();
    return 0 ;
}
void PrintMessage(void){
  printf("A MSG :\n\n");
  printf("Nice day!\n");
}
```



The Function Prototype

- Informs the compiler that there will be a function defined later that:

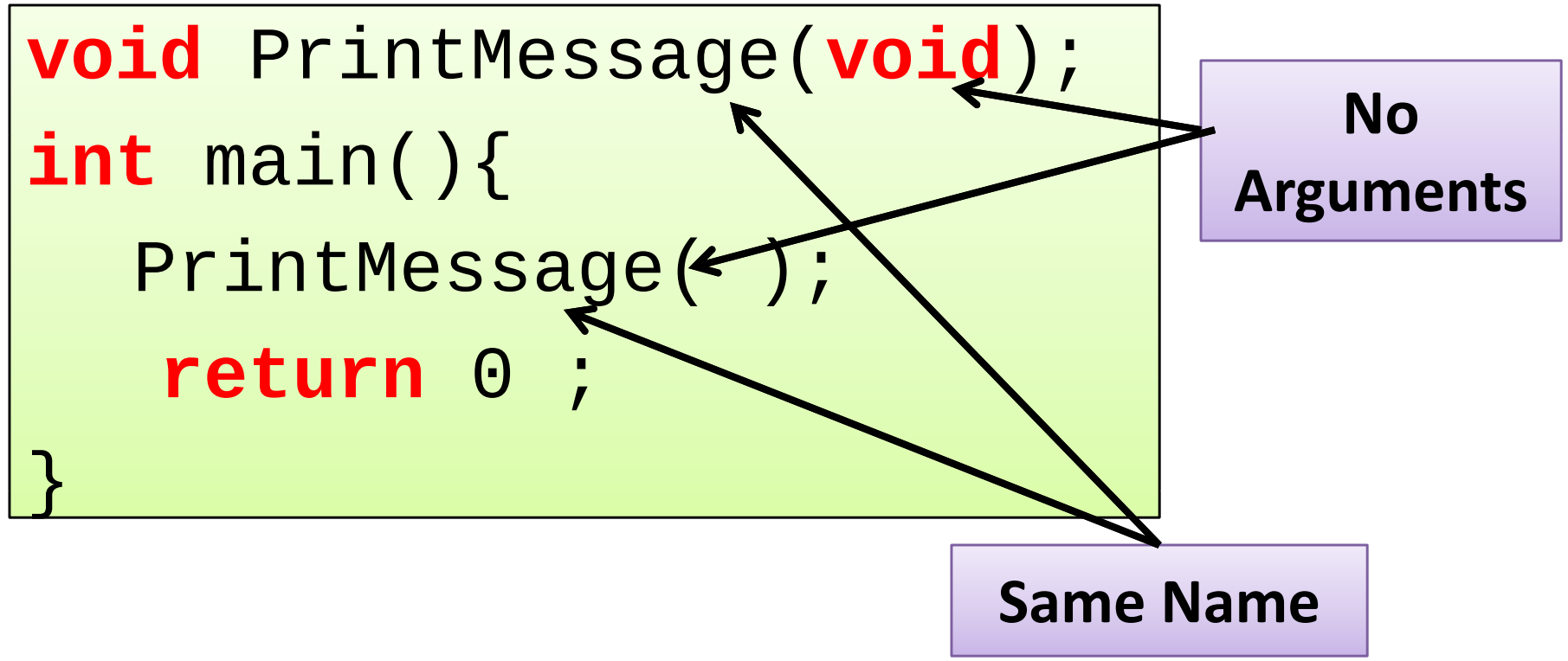


- Needed because the function call is made before the definition -- the compiler uses it to see if the call is made properly

The Function Call

- Passes program control to the function
- Must match the prototype in name, number of arguments, and types of arguments

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



The Function Definition

- Control is passed to the function by function call
  - The statements within the function body will then be executed

```
void PrintMessage(void){
  printf("A MSG :\n\n");
  printf("Nice day!\n");
}
```

- After statements in the function have completed
  - Control is passed back to the **calling function**
- In this case main( )
  - Note that the calling function does not have to be main( ) .

General Function Definition Syntax

type functionName (*parameter*$_1$, . . . , *parameter*$_n$) {
    variable declaration(s)
    statement(s)
}

- If there are no parameters
  - either `functionName()` OR `functionName(void)`
- There may be no variable declarations.
- If the **function type** (**return type**) is void, a return statement is not required
  - Permitted: `return;` OR `return();`

Input Parameters to Function

```
void PrintMessage(int counter) ;

int main ( ){
    int 10;
    PrintMessage(num)
    return 0 ;
}

void PrintMessage(int counter) {
    int i ;
    for (i=0;i<counter; i++)
      printf (“Nice day!\n”) ;
}
```

matches the one **formal parameter** of type int

one argument of type int

Functions Can Return Values : Example

```
#include <stdio.h>
float AverageTwo(int num1,int num2);
int main(){
  float ave ;
  int value1 = 5, value2 = 8 ;
  ave=AverageTwo(value1, value2) ;
  printf("The average of %d & %d
       is %f\n",value1,value2,ave);
 return 0 ;
}
float AverageTwo (int num1, int num2) {
  return  (float)((num1+num2)/2.0) ;
}
```

Temp Convert Function in C

```
double CtoF ( double paramCel){
    return paramCel*1.8+32.0;
}
```

- This function takes an input parameter
  - Called paramCel (temp in degree Celsius)
- Returns a value
  - that corresponds to the temp in degree Fahrenheit

How to use a function?

```
#include <stdio.h>
double CtoF( double );
/*  Purpose: to convert temperature
* from Celsius to Fahrenheit *****/
int main() {
  double c, f;
  printf("Enter the degree (in Celsius): ");
  scanf("%lf", &c);
  f = CtoF(c);
  printf("Temperature (in Fahrenheit)
                              is %lf\n", f);
}
double CtoF ( double paramCel) {
  return paramCel * 1.8 + 32.0;
}
```

Terminology

- **Declaration**

```
double CtoF(double);
```

- **Invocation (Call)**

```
double CtoF(double);
```

- **Definition**

```
duuble CtoF( double paramCel){
    return paramCel*1.8 + 32.0;
 }
```

Modularity: Example

Declarations

```
#include <stdio.h>

double GetTemp();
double CelsToFahr(double);
void DispRes(double,double);

int main(){
  double TempC, TempF;

  TempC=GetTemp();
  TempF=CelsToFahr(TempC);
  DispRes(TempC,TempF);

  return 0;
}
```

Invocations

```
double CelsToFahr(double Tem){
  return (Tem * 1.8 + 32.0);
}
```

```
double GetTemp (){
  double Temp;
  printf("Please enter temp in
       degrees Celsius:");
  scanf("%lf", &Temp);
  return Temp;
}
```

```
void DispRes(double CTemp,
          double Ftemp){
  printf("Original: %5.2f
         C\n", CTemp);
  printf("Equivalent: %5.2f
         F\n", FTemp);
}
```

Abstractions

- We are hiding details on *how* something is done in the function implementation
  - Put in library ☺ ☺ : do you require to know code for printf ? **No**

```
#include <stdio.h>

int main(){
  double TempC, TempF;

  TempC=GetTemp();
  TempF=CelsToFahr(TempC);
  DispRes(TempC,TempF);

  return 0;
}
```

```
double CelsToFahr(double Tem){
  return (Tem * 1.8 + 32.0);
}
```

```
double GetTemp (){
  double Temp;
  printf("Please enter temp in
        degrees Celsius:");
  scanf("%lf", &Temp);
  return Temp;
}
```

```
void DispRes(double CTemp,
          double Ftemp){
  printf("Original: %5.2f
        C\n", CTemp);
  printf("Equivalent: %5.2f
        F\n", FTemp);
}
```

Parameter Passing

- **Actual parameters** are the parameters that appear in the function call

```
ave =AverageTwo(value1,value2) ;
```

- **Formal parameters** are the parameters that appear in the function header

```
float AverageTwo(int num1,int num2)
```

- Actual and formal parameters are matched by position.
- Each formal parameter receives the value of its corresponding actual parameter.

Parameter Passing (cont..)

- Corresponding actual and formal parameters
  - Do not have to have the same name, but they may.
  - Must be of the same data type, with some exceptions, Exception example

```
int fact(int N){ //Code for Fact;}
main(){
      float X=10.34;
      printf("fact of %f is %d",x, fact( X ));
}
```

auto conversion

Local Variables

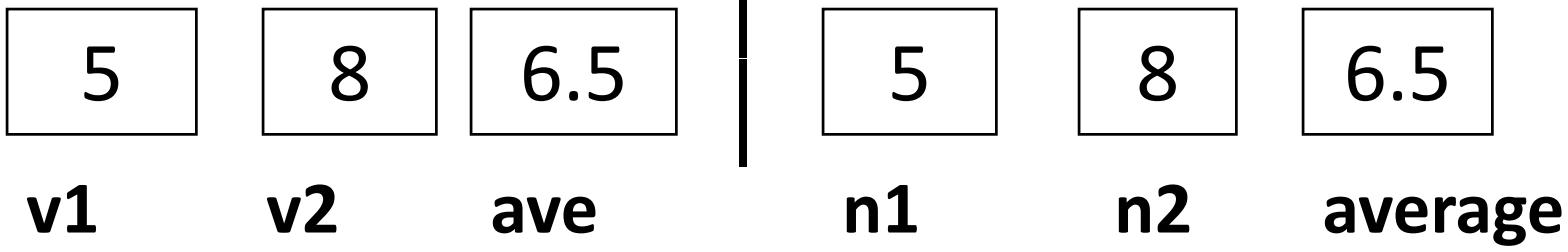
- Functions only “see” (have access to) their own **local variables**. This includes main( )
- Formal parameters are declarations of local variables.
  - The values passed are assigned to those variables.
- Other local variables can be declared within the function body.

Parameter Passing and Local Variables

```
int main(){
  float ave ;
  int v1=5, v2=8 ;
  ave=AvgOfTwo(v1, v2);
  printf ("The average
       is %f\n", ave);
  return 0 ;
}
```

```
float AvgOfTwo(int n1,
               int n2){
  float average;
   average=(n1+n2)/2;
  return average;
}
```

Local copy of variables

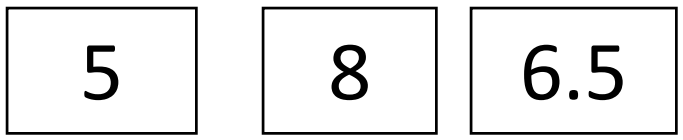


Same Name, Still Different Memory Locations

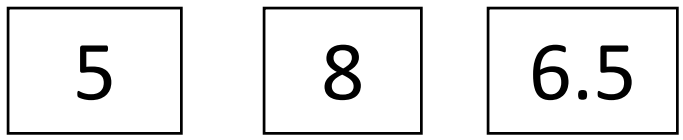
```
int main(){
  float ave ;
  int n1=5, n2=8 ;
  ave=AvgOfTwo(n1, n2);
  printf ("The average
       is %f\n", ave);
  return 0 ;
}
```

```
float AvgOfTwo(int n1,
               int n2){
  float average;
   average=(n1+n2)/2;
  return average;
}
```

Local copy of variables



n1 **n2** **ave**



n1 **n2** **average**

Changes to Local Variables Do NOT Change Other Variables with the Same Name

```
int main(){
   int n1=5;
   AddOne(n1);
   printf ("In main
      n1 is %d\n",n1);
   return 0 ;
}
```

```
void AddOne (int n1){
   n1=n1+1;
   printf ("In AddOneF
      n1 is %d\n",n1);
   return;
}
```

5

n1

6

n1

Local copy of variables

OUTPUT

In AddOneF n1 = 6

In main n1 = 5

Solution : use Pass by reference

```
int main(){
   int n1=5;
   int *Pn1;
   Pn1=&n1;
   AddOne(Pn1);
   printf (“In main
      n1 is %d\n”,n1);
   return 0 ;
}
```

```
void AddOne(
         int *Pn1){
   *Pn1=*Pn1+1;
   printf (“In AddOneF
      n1 is %d\n”,*Pn1);
   return;
}
```

5	&n1
n1	**Pn1**

&n1
Pn1

Local copy of Ptr variables

OUTPUT

In AddOneF n1 = 6

In main n1 = 6

Changes to Local Variables Do NOT Change Other Variables with the Same Name

```
int main(){
   int n1=5, n2=10;
   swap(n1,n2);
   printf ("In main n1=
     %d n2=%d\n",n1,n2);
   return 0 ;
}
```

```
void swap(int n1,
     int n2){
int tmp;
tmp=n1; n1=n2;n2=tmp;
printf ("In main n1=
    %d n2=%d\n",n1,n2);
}
```

Local copy of variables

5	10
n1	**n2**

10	5	5
n1	**n2**	**tmp**

OUTPUT

In swap n1 = 10 n2 =5

In main n1 = 5 n2 =10

Use Pass by Address/Reference

```
int main(){
   int n1=5, n2=10;
   swap(&n1,&n2);
   printf (“In main n1=
     %d n2=%d\n”,n1,n2);
   return 0 ;
}
```

```
void swap(int *Pn1,
     int *Pn2){
int tmp;
tmp=*Pn1;
*Pn1=*Pn2;*Pn2=tmp;
printf (“In main n1=
    %d n2=%d\n”,n1,n2);
}
```

Local copy of variables

5	10
n1	**n2**

&n1	&n2	5
Pn1	**Pn2**	**tmp**

OUTPUT

In swap n1 = 10 n2 =5

In main n1 = 10 n2 =5

Passing Array to Function

```
//(const float *age) (float *age) (float age[6]) same
```

```
 float average(float age[]){
    int i; float avg, sum = 0.0;
    for (i = 0; i < 6; ++i) {
        sum = sum +age[i];  age[i]=1;
    }
    avg = (sum / 6);  return avg;
}
```

```
int main(){
 float avg, age[]={23.4,55,22.6,3,40.5,18};
 int i;
 avg = average(age);
 printf("Average age=%.2f\n", avg);
 for(i=0;i<6;++i) printf("%1.2f“,age[i]);
 return 0 ;
}
```

Storage Classes

- **Storage class specifiers : static, register, auto, extern**
  - Storage duration – how long an object exists in memory
  - Scope – where object can be referenced in program
  - Linkage – specifies the files in which an identifier is known
- **Automatic storage**
  - Object created and destroyed within its block
  - `auto:` default for local variables

```
auto double x, y;
```

  - `register:` tries to put variable into high-speed registers
    - Can only be used for automatic variables

Automatic Storage

- Object created and destroyed within its block
- `auto:` **default for local variables**

```
auto double x, y; //same as double x, y
```

- **Conserving memory**
  - because automatic variables exist only when they are needed.
  - They are created when the function in which they are defined is entered
  - and they are destroyed when the function is exited
- **Principle of least privilege**
  - Allowing access to data only when it is absolutely needed.
  - Why have variables stored in memory and accessible when in fact they are not needed?

Register Storage

- The storage-class specifier **register** can be placed before an automatic variable declaration
  - To suggest that the compiler maintain the variable in one of the computer's high-speed hardware registers.

```
register int counter;
```

  - If intensely used variables such as counters or totals can be maintained in hardware registers
- **Often, register declarations are unnecessary**
  - Today's optimizing compilers are capable of recognizing frequently used variables
  - Can decide to place them in registers without the need for a register declaration

Static storage Classes

- Variables exist for entire program execution
- Default value of zero
- `static`: local variables defined in functions.
  - ***Keep value after function ends***
  - Only known in their own function
- `extern:` default for ***global variables*** and functions
  - Known in any function

Tips for Storage Class

- **Defining a variable as global rather than local**
  - Allows unintended side effects to occur
  - When a function that does not need access to the variable accidentally or maliciously modifies it
- **In general, use of global variables** should be avoided : except in certain situations
- **Variables used only in a particular function**
  - Should be defined as local variables in that function
  - Rather than as external variables.

Scope Rules

- File scope
  - Identifier defined outside function, known in all functions
  - Used for *global variables, function definitions, function prototypes*
- Function scope
  - Can only be referenced inside a function body

Scope Rules

- Block scope
  - Identifier declared inside a block
    - Block scope begins at definition, ends at right brace
  - Used for *variables, function parameters (local variables of function*)
  - **Outer blocks "hidden" from inner blocks if there is a variable with the same name in the inner block**
- Function prototype scope
  - Used for identifiers in *parameter list*

Scope Rule Example

```
int A; //global
int main(){
 A=1;
 MyProc();
 printf("A=%d\n",A);
 return 0 ;
}
void myProc(){
  int A=2;
  while(A==2){
    int A=3;
    printf("A=%d\n",A);
    break;
   }
   printf("A=%d\n",A);
  }
```

Outer blocks "hidden" from inner blocks if there is a variable with the same name in the inner block

Printout:

A = 3

A = 2

A = 1

Scope and Life : Static Vs Global

```
int GA; //global
int main(){
 int i;
 GA=1;
 for(i=1;i<10;i++)
    MyProc();
 printf("GA=%d",GA);
 return 0 ;
}
void myProc(){
   static int SA=2;
   SA=SA+1;
}
```

Both SA and GA Variables exist for entire program execution

- SA initialized once
- SA can be accessible from myProc only
- But GA accessible from any part of Program

Scope Rule Example

```
int FunA(){return 4;}; //global
int main(){

 {
 int FunA(){return 3;};
 pintf("FA=%d\n",FunA());
 }

 pintf("FA=%d\n",FunA());
 return 0 ;
}
```

Outer blocks "hidden" from inner blocks if there is a variable with the same name in the inner block

Printout:

FA = 3

FA = 4

Compile using gcc

This code will not compile using c++/g++ compiler

Memory layout of C program

Dynamic memory allocation

- Reduce wastage of memory
- Useful when data size is unknown before hand
- Array Declaration

```
int A[100];
```

  - **Easy, Not to use pointer**, small size, known before
- Array Creation:
  - Not easy, use of pointer, typecast, **lager size, necessary size**

Memory management C: APIs

- Application program interfaces (APIs)
- Available function/APIs to manage memory
- Create/allocate/reserve space
  - malloc : memory allocation
  - calloc : memory allocation + initialization to 0
- Move a reserved space to another location
  - realloc: move the space to another location
- Destroy/de-allocate/free space
    - free:

Memory Allocation

- Memory can be allocated
- Declaring a variable

```
int A[100];
```

- Explicitly requesting space

```
int *A;
A=(int*)malloc(sizeof(int)*100);
```

Example: Dynamic Array Allocation

- Given N persons (with their IQ level) in order
  - N may be dynamic, variable
- A person decide He/She is intelligent or dumb
- Decides locally:
  - If his/her IQ level is greater than equal to average of IQ level of both neighbors
  - Left neighbor and right neighbor

Example: Dynamic Array Allocation

```
main(){
   int *IQScore, *Intelligent, i, N;
   printf("Input N:"); scanf("%d", &N);
   IQScore=(int*)malloc(N*sizeof(int));
   Intelligent =(int*)calloc(N*sizeof(int));
   for(i=0;i<N;i++)  scanf("%d",&IQScore[i]);
   for(i=1;i<N-1;i++){
       if(IQScore[i]>=(IQScore[i-1]+IQScore[i+1])/2)
         Intelligent[i]=1; else Intelligent[i]=0;
        printf(" I am %d person  %s\n", i,
            Intelligent[i]?"YES":"NO");
   }
   free(IQScore);  free(Intelligent);
   }
```

Memory layout of C program

- Program: Input, Output, Processing
- Code (Instruction), Data (Stack, Heap)
- To store: Require memory
  - Input data, output data, intermediate data
- Memory can be allocated
  - Declaring a variable

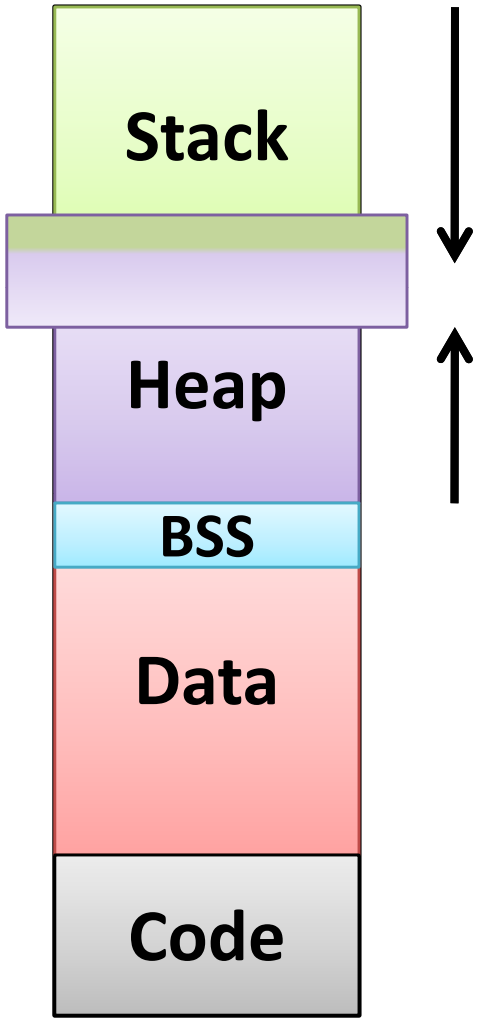
```
int A[100];
```

  - Explicitly requesting space

```
int *A;
A=(int*)malloc(sizeof(int)*100);
```

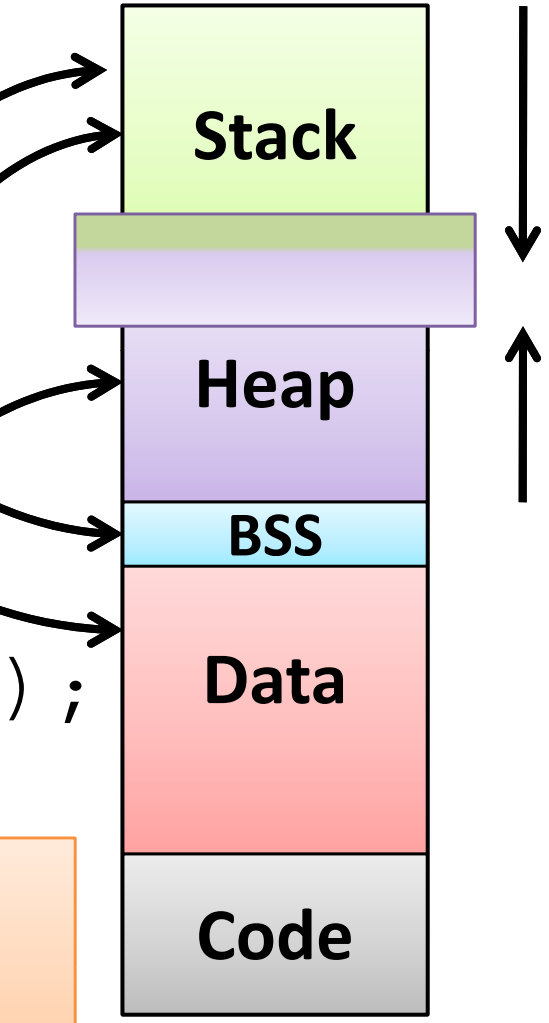
Memory layout of C program

- Stack
  - automatic (default), local
  - Initialized/uninitialized
- Data
  - Global, static, extern
  - BSS: Block Started by Symbol
  - BBS: Uninitialized Data Seg.
- Code : program instructions
- Heap
  - malloc, calloc



Memory layout of C program

```
int A;
int B=10;
main(){
   int Alocal;
   int *p;
   p=(int*)malloc(40);
}
```




```
$gcc  test.c
$size a.out
text    data    bss     dec     hex     filename
1200    544     8       1752    6d8     a.out
```

Examples of
Modular code using Functions

Modular Code for : X^n

```
#include <stdio.h>

int GetNum();
int PowXtoN(int n,int x);
void DispRes(int,int,int);

int main(){
  int X, N, Res;

  X=GetNum();
  N=GetNum();
  Res= PowXtonN(X,N);
  DispRes(Res,X,N);

  return 0;
}
```

```
int PowXtoN(int n, int x){
int n, x, P=1, PS=x;
while(n > 0) {
   if ((n%2)==1) P=P*PS;
    n=n/2; PS = PS* PS;
 }
return P;
}
```

```
int GetANum(){ int N;
  printf("Enter a Number:");
  scanf("%d", &N);
  return N; }
```

```
void DispRes(int Res,
             int X, int N){
  printf("%d to power %d=%d",
         X, N, Res); }
```

Modular C Code : Square root of a Positive Number

```
#include <stdio.h>
float GetAccuracy();
float GetPosNum();
float SqRoot(float,float);
void DispRes(float,float);

int main(){
  float a, e, Res;

  a=GetPosNum();
  e=GetAccuracy();
  Res= SqRoot(a,e);
  DispRes(a, Res);

  return 0;
}
```

```
float SqRoot(float m,
             float e){

float r1, r2;
r1=m/2;
r2=r1;
 while(abs(r1-r2)>e){
      r1=r2;
      r2=(r1+m/r1)/2;
 }
 return r2;
}
```

You need to write code of other functions

Modular C Code : Factorial of a Number

```c
#include <stdio.h>

int GetNum();
int Factorial(int A);
void DispRes(int,int);

int main(){
  int a, Res;

  a=GetNum();
  Res= Factorial(a);
  DispRes(a, Res);

  return 0;
}
```

```c
int Factorial(int n) {

int Prod=1,i;
for (i=1;i<=N;i++){
  Prod=Prod*i;
}

return prod;
}
```

You need to write code of other functions

Modular C Code : Reverse a Number

```
#include <stdio.h>

int GetNum();
int Reverse(int A);
void DispRes(int,int);

int main(){
  int a, Res;

  a=GetNum();
  Res= Reverse(a);
  DispRes(a, Res);

  return 0;
}
```

```
int Reverse(int n) {

int RevNum=0, Rem;
RevNum=0;
while(n != 0)  {
   Rem = n%10;
   RevNum=RevNum*10+ Rem;
   n=n/10;
   }
return RevNum;
}
```

You need to write code of other functions

Modular C Code : Binary Search

```c
#include <stdio.h>
int GetMinOfRange();
int GetMaxOfRange();
int GetUnknown();
int BinSrch(int,
          int, int);
void DispRes(int);
int main(){
 int Min, Max, X, Res;

 Min=GetMinOfRange();
 Max=GetMaxOfRange();
 X=GetUnknown();
 Res=BinSrch(Min,Max,X)
 DispRes(Res);
 return 0;
}
```

```c
int BinSrch(int Rmin, int
  Rmax, int X){

while (Rmin<Rmax){
    mid=(Rmin+Rmax)/2;
    if(X==mid)return mid;
    if (X>mid)
            Rmin=mid+1;
     else Rmax=mid;
    }
    return -1;
}
```

You need to write code of other functions

Modular C Code : Nth Fibonacci

```c
#include <stdio.h>

int GetNum();
int Fib(int N);
void DispRes(int,int);

int main(){
  int N, Res;

  N=GetNum();
  Res= Fib(N);
  DispRes(N, Res);

  return 0;
}
```

```c
int Fib(int N) {

 int fnm2=0; fnm1=1; n=2;
 if(N<=1) return 1;
 while(n<=N){
  fn = fnm2 + fnm1;
  fnm2=fnm1;
  fnm1=fn;
  n = n + 1;
 }
 return fn;
}
```

You need to write code of other functions

Modular C Code : GCD

```c
#include <stdio.h>

int GetA();
int GetB();
int GCD(int A, int B);
Void DisRes(int,int,int);
int main(){
  int a, b, Res;

  a=GetA();
  b=GetB();
  Res= GCD(a,b);
  DisRes(a, b, Res);

  return 0;
}
```

```c
int GCD(int n1, int n2) {

while(!(n1==0|| n2==0)){
      if (n1>n2) n1=n1%n2;
      else n2=n2%n1;
}
if (n1==0) return n2;
else return n1;
}
```

You need to write code of other functions

Modular Code Sin(x)

```
#include <stdio.h>
float GetX();
float GetAccuracy();
float SinXCal(float x,
    float acc);
void DispRes(float,float);

int main(){
  float X, acc, Res;

  X=GetX();
  acc=GetAccuracy();
  Res= SinXCal(X,acc);
  DispRes(X, Res);

  return 0;
}
```

```
float SinXCal(float x,
    float acc){
int i=1;
float SinXVal=0,term=x;
while (term < acc) {
    i = i+2;
    term *= - x*x/(i*(i-1));
    SinxVal= SinxVal+ term;
    }
  return SinXVal;
}
```

You need to write code of other functions

Modular C Code : Value of PI

```c
#include <stdio.h>

int GetABigNumer();
double ValPI(int N);
void
   DispRes(int,float);

int main(){
  int N;
  double Res;
  N=GetABigNumber();
  Res= ValPI(N);
  DispRes(a, b, Res);

  return 0;
}
```

```c
double ValPI(int N){
int M=0,i;
double x,y,z,pi;
for(i=0;i<N;i++){
   x=(double)rand()/RAND_MAX;
   y=(double)rand()/RAND_MAX;
   z = x*x+y*y;
   if (z<=1) M++;
}
 pi=4.0*(double)M/N;
 return pi;
}
```

You need to write code of other functions

Modular C Code : Bisection Method

```
#include <stdio.h>
float GetMinOfInterVal();
float GetMaxOfInterVal();
float GetAccuracy();
float F(float a);
float Bisection(float a,
   float a, float acc)
void DispRes(float,float,float);
int main(){
  float a, b, acc,Res;
  a=GetMinOfInterVal();
  b=GetMaxOfInterVal();
  acc=GetAccuracy();
  Res= Bisection(a,b,acc);
  DispRes(a,b,Res);
  return 0;
}
```

```
float F(float a){
   return a*a*a-2*a-5;
}
```

```
float Bisection(float a,
       float a, float acc){
float Fa, Fb, Fx;
Fa=F(a); Fb=F(b);
x=a; x1=b;
while( abs(x-x1)>accuracy) {
   x1=x; x=(a+b)/2;
   Fx=F(x);
   if(Fa*Fx<0) b=x;else a=x;
   }
 return x;
}
```

You need to write code of other functions

Thanks