CSCI-UA.0201

Computer Systems Organization

C Programming – Basics (Part 2)

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Now that we know about variables, let’s combine them to form expressions!

$$\underbrace{X = \overbrace{2 * Y + Z;}^{\text{Expression}}}_{\text{Statement}}$$

How Expressions Are Evaluated?

Expressions combine Values using Operators, according to precedence.

```
1 + 2 * 2      → 1 + 4      → 5
(1 + 2) * 2    → 3 * 2      → 6
```

Comparison operators are used to compare values.
In C: 0 means "false", and *any other value* means "true".

```
int x=4;
(x < 5)                 → (4 < 5)               → <true>
(x < 4)                 → (4 < 4)               → 0
((x < 5) || (x < 4))    → (<true> || (x < 4))   → <true>
```

Not evaluated because
first clause was true

Precedence

- **Highest to lowest**
  - ()
  - *, /, %
  - +, -

When in doubt, use parenthesis.

Comparison and Mathematical Operators

```
== equal to
<  less than
<= less than or equal
>  greater than
>= greater than or equal
!= not equal
&& logical and
|| logical or
!  logical not
```

```
+   plus
-   minus
*   mult
/   divide
%   modulo
```

```
&   bitwise and
|   bitwise or
^   bitwise xor
~   bitwise not
<<  shift left
>>  shift right
```

More on these in later lectures when we discuss binary numbers.

Beware in division:
If second argument is integer, the result will be integer (rounded):
5 / 10 → 0 *whereas* 5 / 10.0 → 0.5

Don’t confuse & and &&
1 & 2 → 0 *whereas* 1 && 2 → <true>

Assignment Operators

```
x = y    assign y to x
x++      post-increment x
++x      pre-increment x
x--      post-decrement x
--x      pre-decrement x
```

```
x += y   assign (x+y) to x
x -= y   assign (x-y) to x
x *= y   assign (x*y) to x
x /= y   assign (x/y) to x
x %= y   assign (x%y) to x
```

Note the difference between ++x and x++:

```
int x=5;
int y;
y = ++x;
/* x == 6, y == 6 */
```

```
int x=5;
int y;
y = x++;
/* x == 6, y == 5 */
```

Don’t confuse = and ==

```
int x=5;
if (x==6)   /* false */
{
  /* ... */
}
/* x is still 5 */
```

```
int x=5;
if (x=6)   /* always true */
{
  /* x is now 6 */
}
/* ... */
```

Evaluation Order of Expressions

- Unlike many other languages, the semantics of C does not specify the order in which operands are evaluated.
- So be careful when subexpressions have side effects!

Example:

```
int x = 0;
x = x++ + (x + 1);
```

Can be evaluated as

```
int x = 0;
int tmp1 = x++;
int tmp2 = x + 1;
x = tmp1 + tmp2;
// x == 2
```

or

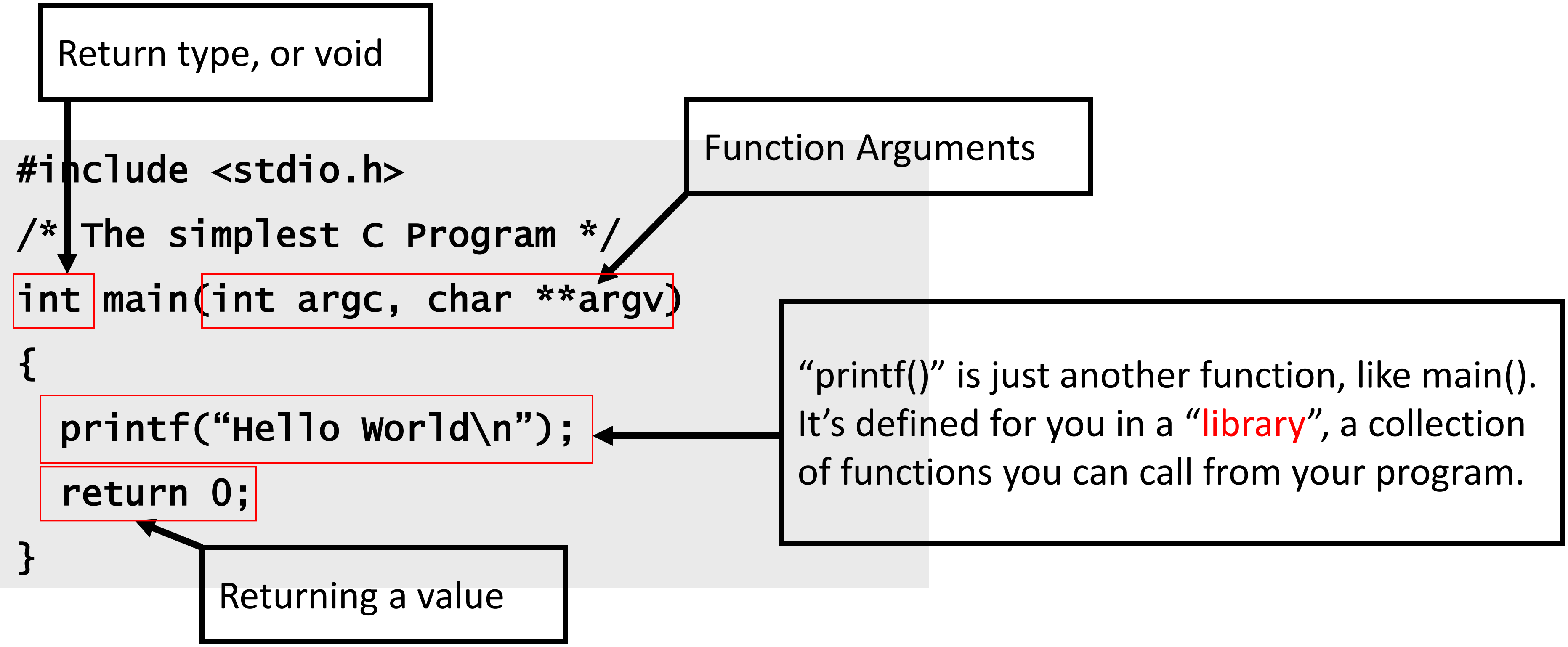
```
int x = 0;
int tmp1 = x + 1;
int tmp2 = x++;
x = tmp2 + tmp1;
// x == 1
```

Functions

What is a Function?

A Function is a series of instructions to run.
You pass Arguments to a function and it returns a Value.

“main()” is a Function. It’s only special because it always gets called first when you run your program.



Return type, or void

Function Arguments

```
#include <stdio.h>
/* The simplest C Program */
int main(int argc, char **argv)
{
  printf(“Hello World\n”);
  return 0;
}
```

“printf()” is just another function, like main(). It’s defined for you in a “library”, a collection of functions you can call from your program.

Returning a value

A More Complex Program: pow

“if” statement

```
/* if evaluated expression is not 0 */
if (expression) {
  /* then execute this block */
}
else {
  /* otherwise execute this block */
}
```

Tracing “pow()”:

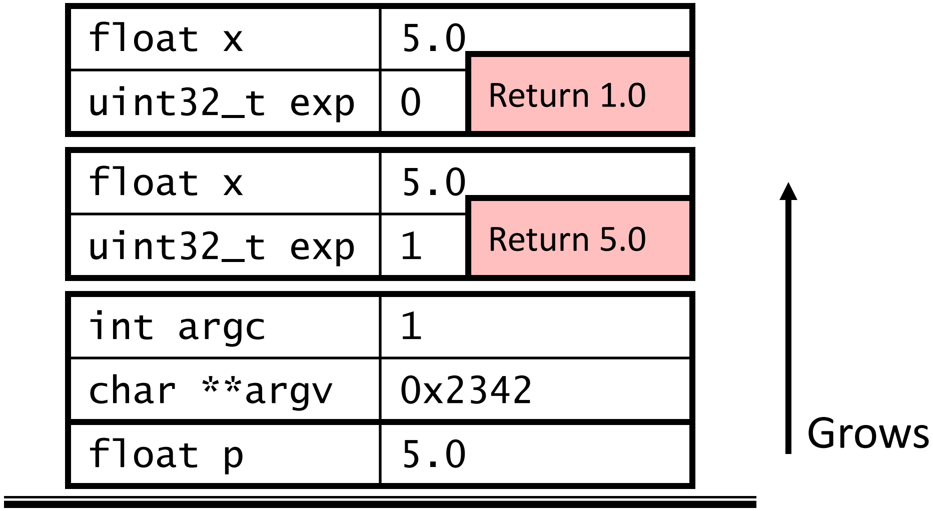
- What does pow(5,0) do?
- What about pow(5,1)?

```
#include <stdio.h>

float pow(float x, unsigned int exp)
{
  /* base case */
  if (exp == 0) {
    return 1.0;
  }

  /* “recursive” case */
  return x*pow(x, exp – 1);
}

int main(int argc, char **argv)
{
  float p;
  p = pow(10.0, 5);
  printf(“p = %f\n”, p);
  return 0;
}
```

The “Stack”

Recall scoping. If a variable is valid “within the scope of a function”, what happens when you call that function recursively? Is there more than one “exp”?

Yes. Each function call allocates a “stack frame” where Variables within that function’s scope will reside.

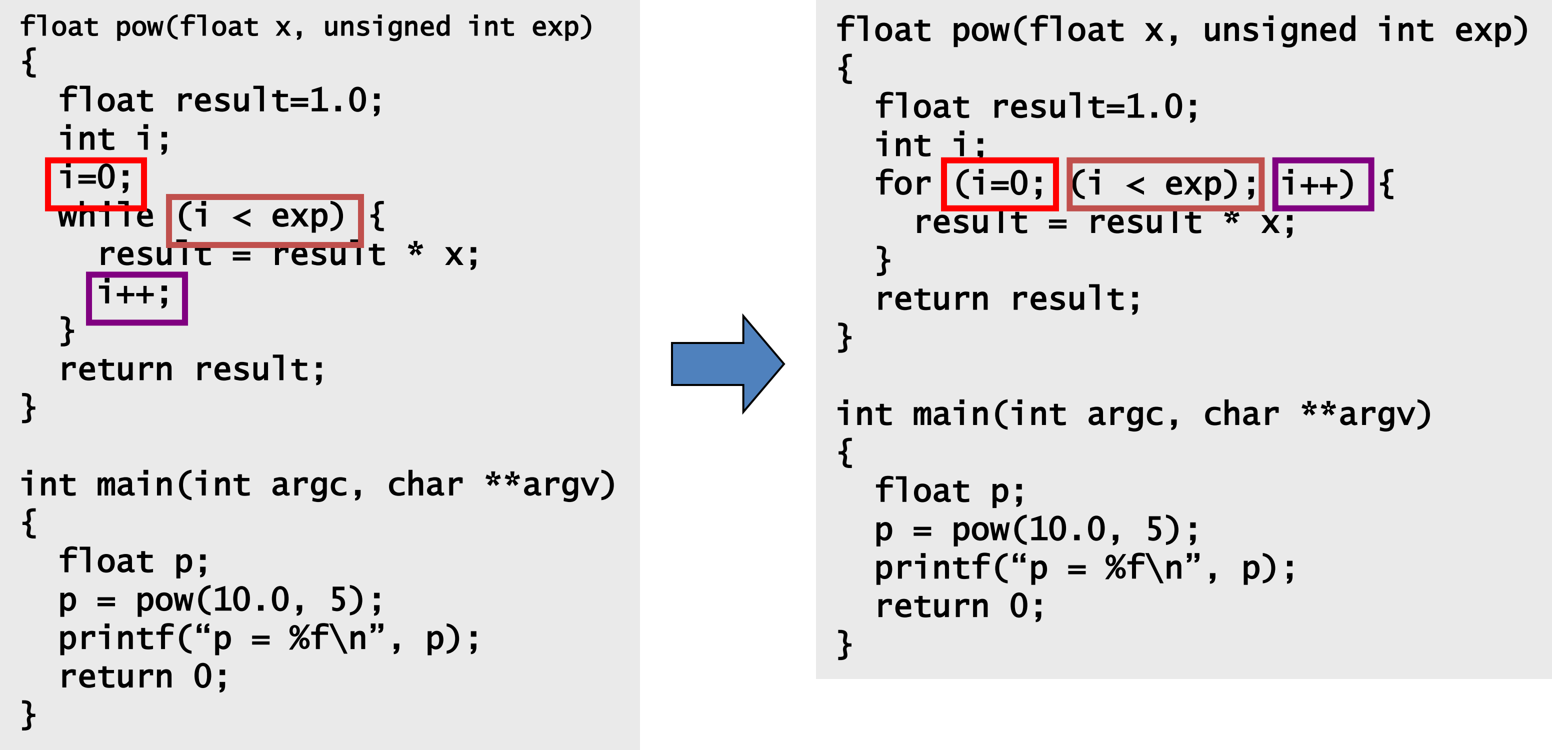


float x	5.0	
uint32_t exp	0	Return 1.0
float x	5.0	
uint32_t exp	1	Return 5.0
int argc	1	
char **argv	0x2342	
float p	5.0	

```
#include <stdio.h>
#include <inttypes.h>

float pow(float x, unsigned int exp)
{
  /* base case */
  if (exp == 0) {
    return 1.0;
  }

  /* “recursive” case */
  return x*pow(x, exp – 1);
}

int main(int argc, char **argv)
{
  float p;
  p = pow(5.0, 1);
  printf(“p = %f\n”, p);
  return 0;
}
```

The “for” loop

The “for” loop is just shorthand for this “while” loop structure.



```
float pow(float x, unsigned int exp)
{
  float result=1.0;
  int i;
  i=0;
  while (i < exp) {
    result = result * x;
    i++;
  }
  return result;
}

int main(int argc, char **argv)
{
  float p;
  p = pow(10.0, 5);
  printf(“p = %f\n”, p);
  return 0;
}
```

```
float pow(float x, unsigned int exp)
{
  float result=1.0;
  int i;
  for (i=0; (i < exp); i++) {
    result = result * x;
  }
  return result;
}

int main(int argc, char **argv)
{
  float p;
  p = pow(10.0, 5);
  printf(“p = %f\n”, p);
  return 0;
}
```

When to Use?

Different Loop-constructs

- while
- do-while
- for

Conditions

- if-else
- switch-case