

Arithmetic Expressions Lesson #1 Outline

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A Less Simple C Program #1

```
/*
*****
*** Program: my_add ***
*** Author: Henry Neeman (hneeman@ou.edu) ***
*** Course: CS 1313 010 Fall 2017 ***
*** Lab: Sec 014 Fridays 2:30pm ***
*** Description: Input two integers, compute ***
*** their sum and output the result. ***
*****
*/
#include <stdio.h>
int main ()
{ /* main */
  /*
  *****
  *** Declaration Section ***
  *****
  *
  *****
  * Named Constant Subsection *
  *****
  */
  const int program_success_code = 0;
  /*
  *****
  * Local Variable Subsection *
  *****
  *
  * addend: the addend value that the user inputs.
  * augend: the augend value that the user inputs.
  * sum: the sum of the addend and the augend,
  * which is output.
  */
  int addend, augend, sum;
```

Continued on
the next slide.



A Less Simple C Program #2

```
/*
*****
*** Execution Section ***
*****
*
*****
* Greeting Subsection *
*****
*
* Tell the user what the program does.
*/
printf("I'll add a pair of integers.\n");
/*
*****
* Input subsection *
*****
*
* Prompt the user to input the addend & augend.
*/
printf("What pair of integers do you want to add?\n");
/*
* Input the integers to be added.
*/
scanf("%d %d", &addend, &augend);
```

Continued on
the next slide.



A Less Simple C Program #3

```
/*
*****
* Calculation Subsection *
*****
*
* Calculate the sum.
*/
sum = addend + augend;
/*
*****
* Output Subsection *
*****
*
* Output the sum.
*/
printf("The sum of %d and %d is %d.\n",
      addend, augend, sum);
return program_success_code;
} /* main */
```

The statement as a whole is an assignment statement.

The stuff to the right of the equals sign is an arithmetic expression.



A Less Simple C Program #4

```
#include <stdio.h>
int main ()
{ /* main */
    const int program_success_code = 0;
    int addend, augend, sum;

    printf("I'll add a pair of integers.\n");
    printf("What pair of integers do you want to add?\n");
    scanf("%d %d", &addend, &augend);
    sum = addend + augend;
    printf("The sum of %d and %d is %d.\n",
           addend, augend, sum);
    return program_success_code;
} /* main */
```

The statement as a whole is an **assignment statement**.

The stuff to the right of the single equals sign is an **arithmetic expression**.



A Less Simple C Program: Compile & Run

```
% gcc -o my_add my_add.c
```

```
% my_add
```

```
I'll add a pair of integers.
```

```
What pair of integers do you want to add?
```

```
5 7
```

```
The sum of 5 and 7 is 12.
```

```
% my_add
```

```
I'll add a pair of integers.
```

```
What two integers do you want to add?
```

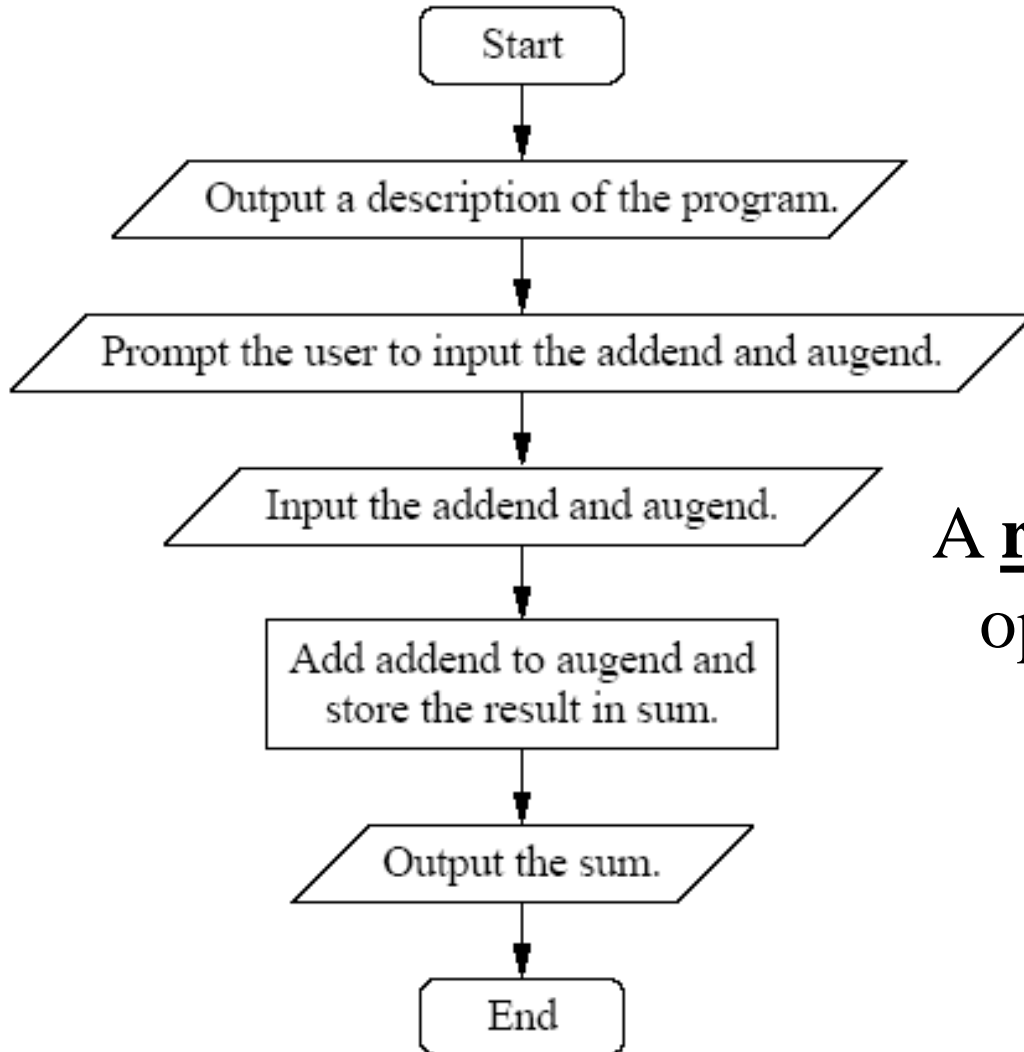
```
1593
```

```
09832
```

```
The sum of 1593 and 9832 is 11425.
```



Flowchart for my_add.c



A rectangle denotes an operation other than I/O or branching (for example, calculation).



Named Constant Example Program

```
% cat circlecalc.c
#include <stdio.h>
int main ()
{ /* main */
    const float pi                = 3.1415926;
    const float diameter_factor   = 2.0;
    const int   program_success_code = 0;
    float radius, circumference, area;

    printf("I'm going to calculate a circle's\n");
    printf(" circumference and area.\n");
    printf("What's the radius of the circle?\n");
    scanf("%f", &radius);
    circumference = pi * radius * diameter_factor;
    area = pi * radius * radius;
    printf("The circumference is %f\n", circumference);
    printf(" and the area is %f.\n", area);
    return program_success_code;
} /* main */
% gcc -o circlecalc circlecalc.c
% circlecalc
I'm going to calculate a circle's
 circumference and area.
What's the radius of the circle?
5
The circumference is 31.415924
and the area is 78.539810.
```



Named Constant Example Program

```
% cat circlecalc.c
#include <stdio.h>
int main ()
{ /* main */
    const float pi                = 3.1415926;
    const float diameter_factor   = 2.0;
    const int   program_success_code = 0;
    float radius, circumference, area;

    printf("I'm going to calculate a circle's\n");
    printf(" circumference and area.\n");
    printf("What's the radius of the circle?\n");
    scanf("%f", &radius);
    circumference = pi * radius * diameter_factor;
    area = pi * radius * radius;
    printf("The circumference is %f\n", circumference);
    printf(" and the area is %f.\n", area);
    return program_success_code;
} /* main */
% gcc -o circlecalc circlecalc.c
% circlecalc
I'm going to calculate a circle's
 circumference and area.
What's the radius of the circle?
5
The circumference is 31.415924
 and the area is 78.539810.
```



1997 Tax Program with Named Constants

```
% cat tax1997_named.c
#include <stdio.h>

int main ()
{ /* main */
    const float standard_deduction    = 4150.0;
    const float single_exemption      = 2650.0;
    const float tax_rate               = 0.15;
    const int   tax_year               = 1997;
    const int   program_success_code  = 0;
    float income, tax;

    printf("I'm going to calculate the federal income tax\n");
    printf("  on your %d income.\n", tax_year);
    printf("What was your %d income in dollars?\n", tax_year);
    scanf("%f", &income);
    tax = (income - (standard_deduction + single_exemption)) * tax_rate;
    printf("The %d federal income tax on $%2.2f\n", tax_year, income);
    printf("  was $%2.2f.\n", tax);
    return program_success_code;
} /* main */

% gcc -o tax1997_named tax1997_named.c
% tax1997_named
I'm going to calculate the federal income tax
  on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
  was $1980.00.
```



What is an Expression? #1

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an *expression* is a combination of:

- *Operands*
- *Operators*
- *Parentheses*: ()

Not surprisingly, an expression in a program can look very much like an expression in math (though not necessarily identical). This is on purpose.

NOTE: In C, the only characters you can use for parenthesizing are **actual parentheses** (unlike in math, where you can also use square brackets and curly braces as well.)



What is an Expression? #2

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an *expression* is a combination of:

- *Operands*, such as:
 - Literal constants
 - Named constants
 - Variables
 - *Function invocations* (which we'll discuss later)
- *Operators*
- *Parentheses*: ()



What is an Expression? #3

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an *expression* is a combination of:

- *Operands*
- *Operators*, such as:
 - Arithmetic Operators
 - Relational Operators
 - Logical Operators
- *Parentheses*: ()



What is an Expression? #4

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an *expression* is a combination of:

- *Operands*
- *Operators*, such as:
 - Arithmetic Operators
 - Addition: +
 - Subtraction: -
 - Multiplication: *
 - Division: /
 - *Modulus* (remainder): % (only for `int` operands)
 - Relational Operators
 - Logical Operators
- *Parentheses*: ()



What is an Expression? #5

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an *expression* is a combination of:

- *Operands*
- *Operators*, such as:
 - Arithmetic Operators
 - Relational Operators
 - Equal: ==
 - Not Equal: !=
 - Less Than: <
 - Less Than or Equal To: <=
 - Greater Than: >
 - Greater Than or Equal To: >=
 - Logical Operators
- *Parentheses*: ()



What is an Expression? #6

$a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$

In programming, an **expression** is a combination of:

- **Operands**
 - **Operators**, such as:
 - Arithmetic Operators
 - Relational Operators
 - Logical Operators
 - **Negation** (NOT): !
 - **Conjunction** (AND): &&
 - **Disjunction** (OR): ||
 - **Parentheses**: ()
- ← We'll learn about these later.



What is an Arithmetic Expression? #1

An *arithmetic expression* (also called a *numeric expression*) is a combination of:

- *Numeric operands*
- *Arithmetic Operators*
- *Parentheses*: ()



What is an Arithmetic Expression? #2

An *arithmetic expression* (also called a *numeric expression*) is a combination of:

- *Numeric operands*, such as:
 - int & float literal constants (**BAD BAD BAD**)
 - int & float named constants (**GOOD**)
 - int & float variables
 - int-valued & float-valued *function invocations*
- *Arithmetic Operators*
- *Parentheses*: ()



What is an Arithmetic Expression? #3

An arithmetic expression (also called a numeric expression) is a combination of:

- Numeric operands
- Arithmetic Operators, such as:
 - Identity: +
 - Negation: -
 - Addition: +
 - Subtraction: -
 - Multiplication: *
 - Division: /
 - Modulus (remainder): % (only for `int` operands)
- Parentheses: ()



Arithmetic Expression Examples

x

+x

-x

x + y

x - y

x * y

x / y

x % y

x + y - (z % 22) * 7 / cos(theta)



Unary & Binary Arithmetic Operations

Arithmetic operations come in two varieties:

unary and binary.

A unary operation is an operation that has only one operand.

For example:

$$-x$$

Here, the operand is x , the operator is the minus sign, and the operation is negation.

A binary operation uses two operands. For example:

$$y + z$$

Here, the operands are y and z , the operator is the plus sign, and the operation is addition.



Arithmetic Operations

| Operation | Kind | Operator | Usage | Value |
|-----------------------|--------|-----------|---------|--|
| Identity | Unary | + none | +x x | Value of x Value of x |
| Negation | Unary | - | -x | Additive inverse of x |
| Addition | Binary | + | x + y | Sum of x and y |
| Subtraction | Binary | - | x - y | Difference between x and y |
| Multiplication | Binary | * | x * y | Product of x times y (i.e., $x \cdot y$) |
| Division | Binary | / | x / y | Quotient of x divided by y (i.e., $x \div y$) |
| Modulus (int only) | Binary | % | x % y | Remainder of x divided by y (i.e., $x - \lfloor x \div y \rfloor \cdot y$) |



Structure of Arithmetic Expressions #1

An arithmetic expression can be long and complicated. For example:

$$a + b - c * d / e \% f$$

Terms and **operators** can be mixed together in almost limitless variety, but they must follow the rule that a unary operator has a term immediately to its right and a binary operator has terms on both its left and its right:

$$-a + b - c * d / e \% f - (398 + g) * 5981 / 15 \% h$$

Parentheses can be placed around any unary or binary **subexpression**:

$$((-a) + b - c) * d / e \% f - ((398 + g) * 5981 / 15) \% h$$



Structure of Arithmetic Expressions #2

Putting a term in **parentheses** may change the value of the expression, because a term inside parentheses will be **calculated first**.

For example:

$a + b * c$ is evaluated as

“multiply b by c, then add a,” but

$(a + b) * c$ is evaluated as

“add a and b, then multiply by c”

Note: As a general rule, you **cannot** put two operators in a row (but we’ll see exceptions, sort of).



int-valued & float-valued Expressions

An *int-valued expression* is an expression that, when it is evaluated, has an `int` result.

A *float-valued expression* is an expression that, when it is evaluated, has a `float` result.



Precedence Order

In the absence of parentheses that explicitly state the order of operations, the *order of precedence* (also known as the *order of priority*) is:

- **first**: multiplication and division, left to right, and then
- **second**: addition, subtraction, identity and negation, left to right.

After taking into account the above rules, the expression as a whole is evaluated left to right.



Precedence Order Examples

- $1 - 2 - 3 = -1 - 3 = -4$ but
 $1 - (2 - 3) = 1 - (-1) = 2$
- $1 + 2 * 3 + 4 = 1 + 6 + 4 = 7 + 4 = 11$ but
 $(1 + 2) * 3 + 4 = 3 * 3 + 4 = 9 + 4 = 13$
- $24 / 2 * 4 = 12 * 4 = 48$ but
 $24 / (2 * 4) = 24 / 8 = 3$
- $5 + 4 \% 6 / 2 = 5 + 4 / 2 = 5 + 2 = 7$ but
 $5 + 4 \% (6 / 2) = 5 + 4 \% 3 = 5 + 1 = 6$ but
 $(5 + 4) \% (6 / 2) = 9 \% (6 / 2) = 9 \% 3 = 0$

Rule of Thumb: If you can't remember the precedence order of the operations, use lots of parentheses.

But **DON'T** overdo your use of parentheses, because then your code will be “write only.”



Precedence Order Example: int #1

```
#include <stdio.h>

int main ()
{ /* main */
    printf("1 - 2 - 3 = %d\n", 1 - 2 - 3);
    printf("1 - (2 - 3) = %d\n", 1 - (2 - 3));
    printf("\n");
    printf(" 1 + 2 * 3 + 4 = %d\n", 1 + 2 * 3 + 4);
    printf("(1 + 2) * 3 + 4 = %d\n", (1 + 2) * 3 + 4);
    printf("\n");
    printf("24 / 2 * 4 = %d\n", 24 / 2 * 4);
    printf("24 / (2 * 4) = %d\n", 24 / (2 * 4));
    printf("\n");
    printf(" 5 + 4 % 6 / 2 = %d\n", 5 + 4 % 6 / 2);
    printf(" 5 + 4 % (6 / 2) = %d\n", 5 + 4 % (6 / 2));
    printf("(5 + 4) % (6 / 2) = %d\n", (5 + 4) % (6 / 2));
} /* main */
```

Notice that a `printf` statement can output the value of an expression.



Precedence Order Example: int #2

```
% gcc -o int_expressions int_expressions.c
```

```
% int_expressions
```

```
1 - 2 - 3 = -4
```

```
1 - (2 - 3) = 2
```

```
1 + 2 * 3 + 4 = 11
```

```
(1 + 2) * 3 + 4 = 13
```

```
24 / 2 * 4 = 48
```

```
24 / (2 * 4) = 3
```

```
5 + 4 % 6 / 2 = 7
```

```
5 + 4 % (6 / 2) = 6
```

```
(5 + 4) % (6 / 2) = 0
```



Precedence Order Example: float #1

```
#include <stdio.h>

int main ()
{ /* main */
    printf("1.0 - 2.0 - 3.0 = %f\n", 1.0 - 2.0 - 3.0);
    printf("1.0 - (2.0 - 3.0) = %f\n", 1.0 - (2.0 - 3.0));
    printf("\n");
    printf(" 1.0 + 2.0 * 3.0 + 4.0 = %f\n",
           1.0 + 2.0 * 3.0 + 4.0);
    printf("(1.0 + 2.0) * 3.0 + 4.0 = %f\n",
           (1.0 + 2.0) * 3.0 + 4.0);
    printf("\n");
    printf("24.0 / 2.0 * 4.0 = %f\n", 24.0 / 2.0 * 4.0);
    printf("24.0 / (2.0 * 4.0) = %f\n", 24.0 / (2.0 * 4.0));
} /* main */
```

Again, notice that a `printf` statement can output the value of an expression.



Precedence Order Example: float #2

```
% gcc -o real_expressions real_expressions.c
```

```
% real_expressions
```

```
1.0 - 2.0 - 3.0 = -4.000000
```

```
1.0 - (2.0 - 3.0) = 2.000000
```

```
1.0 + 2.0 * 3.0 + 4.0 = 11.000000
```

```
(1.0 + 2.0) * 3.0 + 4.0 = 13.000000
```

```
24.0 / 2.0 * 4.0 = 48.000000
```

```
24.0 / (2.0 * 4.0) = 3.000000
```

