Exercise 6: Three Address Code Generation

Learning Outcomes

- Learn the concept predictive parsers in context free grammars.
- Understand if a given grammar is left recursive or not.
- Create a program to eliminate left recursion.

Task: Write a program to generate three address code from a given expression

Three-address code (often abbreviated to TAC or 3AC) is an intermediate code used by optimizing compilers to aid in the implementation of code-improving transformations. Three address code is easy to generate and can be easily converted to machine code. It makes use of at most three addresses and one operator to represent an expression and the value computed at each instruction is stored in a temporary variable generated by the compiler. The compiler decides the order of operation givenby three address code.

General representation of TAC:

a = b op c

Where a, b, or c represents operands like names, constants, or compiler-generated temporariesand op represents the operator.

Example:

x = (-b + sqrt(b^2 - 4*a*c)) / (2*a)

TAC of Example:

```
t1 := b * b
t2 := 4 * a
t3 := t2 * c
t4 := t1 - t3
t5 := sqrt(t4)
t6 := 0 - b
t7 := t5 + t6
t8 := 2 * a
t9 := t7 / t8
x := t9
```

Implementation Details:

Precedence:

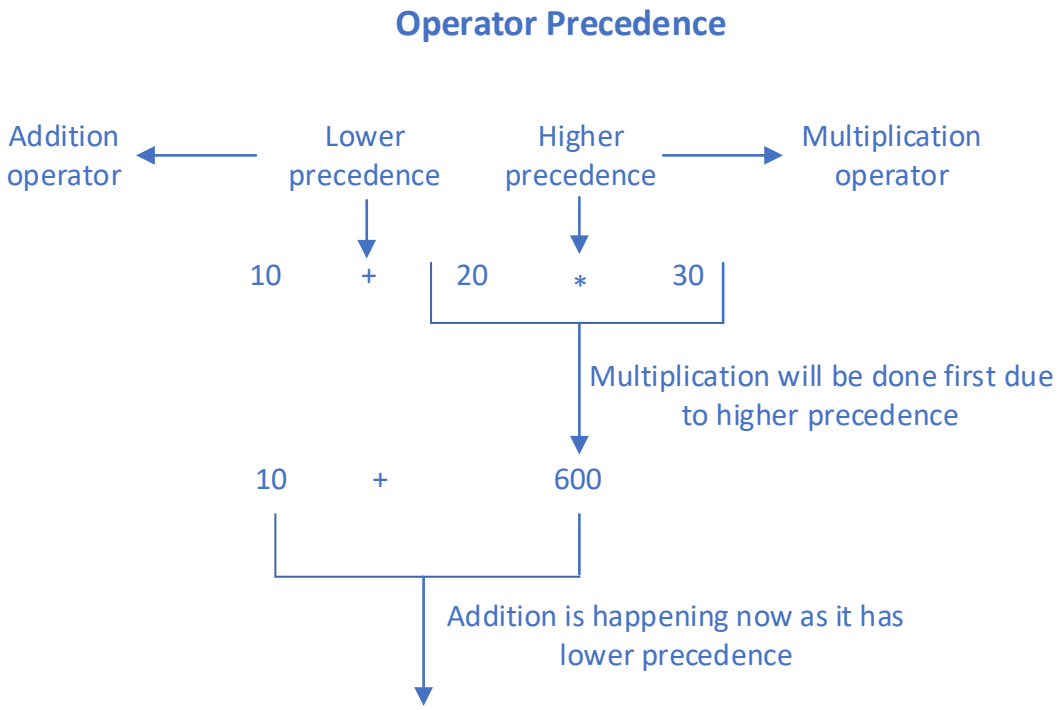
While implementing the TAC, the first thing to keep in mind is precedence. **Precedence/ order of operations** is a collection of rules that reflect conventions about which procedures

to performfirst in order to evaluate a given mathematical expression.

The precedence of an operator specifies how "tightly" it binds two expressions together. For example, in the expression 1 + 5 * 3, the answer is 16 and not 18 because the multiplication ("*")operator has higher precedence than the addition ("+") operator. Parentheses may be used toforce precedence, if necessary. For instance: (1 + 5) * 3 evaluates to 18.

Example:

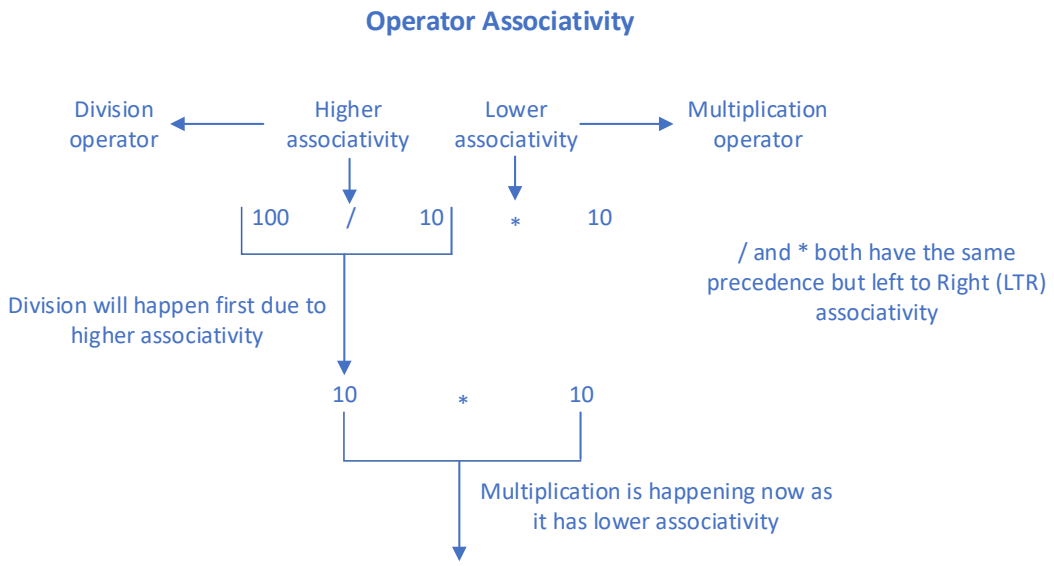
Solve: 10 + 20 * 30



Left associativity:

Operators Associativity is used when two operators of the same precedence appear in an expression. Associativity can be either Left to Right or Right to Left.

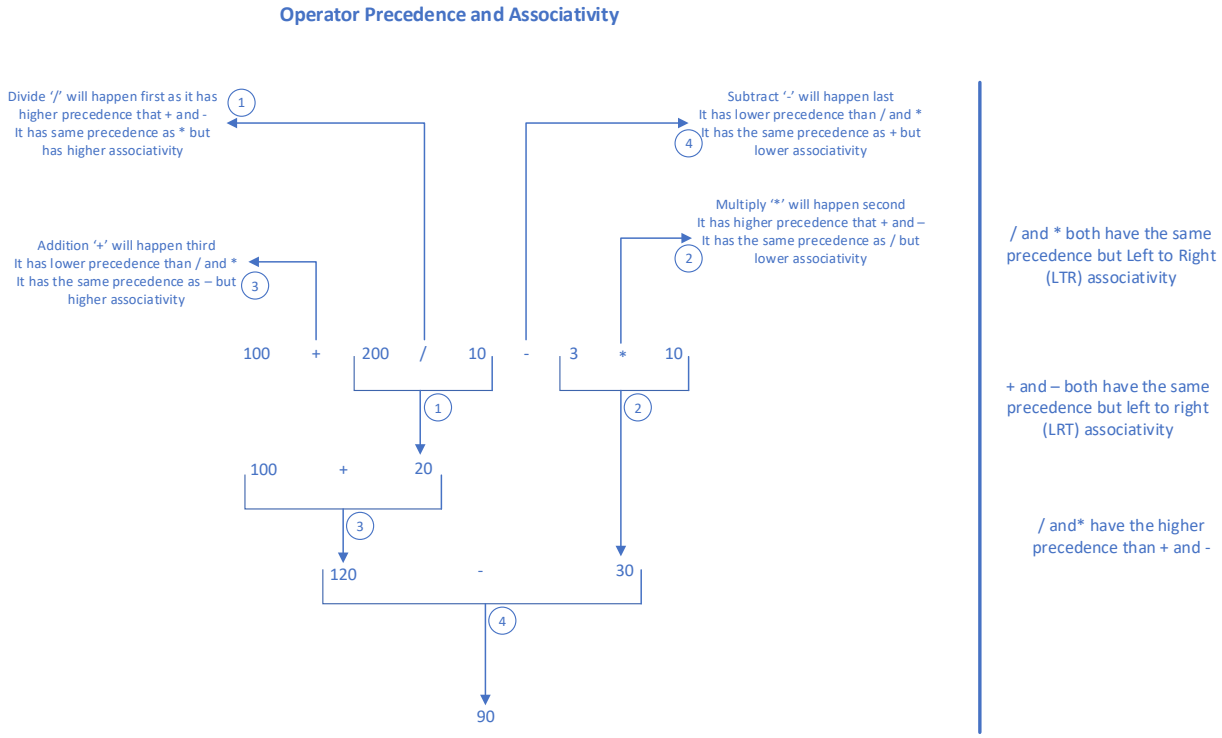
For example: '*' and '/' have the same precedence and their associativity is Left to Right, so the expression "100 / 10 * 10" is treated as "(100 / 10) * 10".



Operators Precedence and Associativity are two characteristics of operators that determine theevaluation order of sub-expressions in absence of brackets.

Example:

100 + 200 / 10 - 3 * 10



Things to Remember:

1) Associativity is only used when there are two or more operators of the same precedence.
2) All operators with the same precedence have the same associativity.
3) Precedence and associativity of postfix ++ and prefix ++ are different.

Precedence	Operator	Description	Associativity
1	++ --	Suffix/postfix increment and decrement	Left-to-right
	()	Function call	
	[]	Array subscripting	
	.	Structure and union member access	
	->	Structure and union member access through pointer	
	(*type*){*list*}	Compound literal	
2	++ --	Prefix increment and decrement	Right-to-left
	+ -	Unary plus and minus	
	! ~	Logical NOT and bitwise NOT	
	(*type*)	Cast	
	*	Indirection (dereference)	
	&	Address-of	
	sizeof	Size-of	
	_Alignof	Alignment requirement	
3	* / %	Multiplication, division, and remainder	Left-to-right
4	+ -	Addition and subtraction	
5	<< >>	Bitwise left shift and right shift	
6	< <=	For relational operators < and ≤ respectively	
	> >=	For relational operators > and ≥ respectively	
7	== !=	For relational = and ≠ respectively	
8	&	Bitwise AND	
9	^	Bitwise XOR (exclusive or)	
10	|	Bitwise OR (inclusive or)	
11	&&	Logical AND	
12	||	Logical OR	
13	?:	Ternary conditional	Right-to-left
14	=	Simple assignment	

It is good to know precedence and associativity rules, but the best thing is to use brackets, especially for less commonly used operators (operators other than +, -, *.. etc). Brackets increase the readability of the code as the reader doesn't have to see the table to find out the order.

For simplicity in this experiment, use only first brackets and arithmetic operators (^, *,/,+,-, %,
=) and some unary operators.

Input:

You should take inputs from a file/console.

```
-(a x b) + (c + d) – (a + b + c + d)
```

Output:

```
(1) T1 = a x b
(2) T2 = uminus T1
(3) T3 = c + d
(4) T4 = T2 +T3
(5) T5 = a + b
(6) T6 = T3 + T5
(7) T7 = T4
```