

## Lecture 02

### Mathematical Expressions

It is hard to make programs without mathematical expressions. Almost every program has some mathematical expressions and there is the point where programmers have a great margin to do mistake (what we call logical errors). A mathematical expression has essentially two things: **Operands** and **Operators**. The third possible thing is **parentheses** (sometimes also refer to operator) use to prioritize some sub-expression. Apart from typing wrong values like 12 instead of 120 or 21 and typing wrong operators (instead of + - is used) a critical error is to wrong considerations of priorities of operators which plays a vital role in expression solving. For example **2+3\*5** can give different result if solved left to right or right to left, for example in this statement **25** is answer if solved left to right (surely wrong), and **17** is answer if solved right to left (which is correct). This is interesting that that saying we are solving expression from right to left is absolutely wrong. Rather we are solving sub-expression **3\*5** first, shortly we will see why?

Since my elementary school I hate rote learning, but luckily I like mathematics a lot and have faced no problem doing mathematics yet not remembering rules very much. While teaching programming and telling students about mathematical expressions many students say “Oh, you are talking about DMAS” that is Division, Multiplication, Addition and Subtraction. DMAS is right but most of the students has wrong understanding of DMAS that division is prioritize over multiplication, it is wrong, rather Division and Multiplication have same priority; whereas; Addition and Subtraction has same priority. There are five arithmetic operators (+, -, \*, /, %) in Java, some languages also have another operator for exponentiation. Therefore the basic rules to solve the expressions are: (We will shortly discuss % (remainder) operator and integer division)

1. Expression is solved left to right like:

$$5+3-4+1 = 8-4+1 = 4+1 = 5$$

2. If there are operators \*, /, % they have priority over + and – operator therefore they should be solve left to right but before + and -. Like:

$$5+3*4 = 5 + 12 = 17$$

$$5*8/4 = 40 / 4 = 10$$

You may be thinking that second expression will give same result if solved right to left you are correct but this is not true in general especially if we distinguish integers and real numbers and we have to distinguish them

3. Parentheses has highest precedence, whenever there are parentheses we have to solve them before rest of the expression and in case there is nested parentheses first inner parentheses are solved than outer. See some examples:

$$5*(3+4) = 5 * 7 = 35$$

$$36/(3*(6-2)) = 36 / ( 3 * 4 ) = 36 / 12 = 3$$

**Warning:** Students should understand they are not doing mathematics, therefore, they should not right  $\frac{8}{4}$  rather they should write 8/4, also 4(2+3) is incorrect, one must insert multiplication operator

between 4 and opening parentheses thus correct expression is  $4*(2+3)$ . A simple rule is if there are **k** operands there must be **k-1** operators in a correct expression.

### Integer and Real Numbers in Expression Solving:

In mathematics we have different treatment of integers and real numbers but unfortunately student has normally no idea about integer division. That is  $5/2=2$  not 2.5 and  $7/4=1$  not 1.75 but  $6/3=2$  obviously. Whereas  $5/2.0=2.5$  and  $10/2.5=4$ . Therefore first of all we will consider expression solving using integers.

Integers are whole numbers having no fractional part and use to represent all items which are not divisible in fractions like if we want to divide 10 markers in 4 persons equally, we cannot give 2.5 markers to each, rather to divide them equally we will say that each person will receive 2 markers and 2 markers will remain undivided. Similarly if we want to distribute 50 persons in 4 teams equally we can give 12 persons to each team and 2 persons will remain. So far you can understand that in any expression if we have only integers we have to be very careful about integer division; whereas; other operators will work as you already use to. Let's consider some examples:

$$7+8/5-3 = 7 + 1 - 3 = 8 - 3 = 5$$

$$2*9/4+5 = 18 / 4 + 5 = 4 + 5 = 9$$

$$3*(12/5) = 3 * 2 = 6$$

Real numbers is a larger set as compare to integers as they include integers, plus set of real numbers include numbers having fractional part as well like 3.25, -4.78 etc. In case of real numbers division is a complete division with zero remainder. Like  $6/4.0 = 1.5$  or  $7.0/4 = 1.75$  or  $5.0/2.0 = 2.5$ . Two points are important to consider here, one is if an integer is written with period and zero on right hand side it will no more is an integer, it is real number, I mean 4 is an integer; whereas; 4.0 is real. Secondly in any calculation if there is one of the operands or both operands are real result will be real. Students must also concentrate that if we have a single real number in an expression result will be real. As compare to integer division you are very much familiar with real number calculation but we will consider some examples just for revision:

$$7+8/5.0-3 = 7 + 1.6 - 3 = 8.6 - 3 = 5.6$$

$$2*9.0/4+5 = 18.0 / 4 + 5 = 4.5 + 5 = 9.5$$

$$3*(12/5) = 3 * 2.4 = 7.2$$

In last three expression first two have just addition of fractional part in answer but it is very clear in 3<sup>rd</sup> expression that due to real division answer is substantially changed. We have discussed another operator (%) not very much known to people not use to with computer programming. Interestingly almost every language provides % remainder operator. Let's consider some expressions involving % operator, just consider that because % is related to division, therefore, it has same precedence as '/' and '\*' operators.

$$7\%4 = 3$$

$$8\%5*6 = 3 * 6 = 18$$

## First Java Program:

```
class FirstProgram{  
    public static void main(String []args){  
        System.out.println("Starting first program with name of Allah! ");  
        System.out.println(3+5*6);  
        System.out.println("End of first program!");  
    }  
}
```

Steps to write, compile and execute java program:

1. Open Textpad [software to write, compile and execute java program]
2. Type above program as it [Taking care of capital and small letters]
3. Save this program with name "FirstProgram.java" [select java from save as type]
4. Press Ctrl+1 keys to compile this program: [or use menu Tools->External Tools->Compile Java]
  - a. If you see message "Tool completed successfully" then go to step 5
  - b. else correct mistake and repeat step 4
5. Press Ctrl+2 keys to run this program [or use menu Tools->External Tools->Run Java Application]