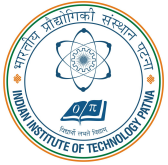
Expressions



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Expressions

- Variables and constants are linked with operators
  - Arithmetic expressions
    - Uses arithmetic operators
    - Can evaluate to any value
  - Logical expressions
    - Uses relational and logical operators
    - Evaluates to 1 or 0 (true or false) only
  - Assignment expression
    - Uses assignment operators
    - Evaluates to value depending on assignment

Arithmetic operators

- Binary operators
  - Addition +
  - Subtraction −
  - Division /
  - Multiplication *
  - Modulus %
- Unary operators
  - Plus +
  - Minus +

- Examples:

```
2*3+5-10/3
-1+3*3/19-7
distance/time
a*x*x+b*x+c
37%10
3.14*radius*radius
```

Example

- Suppose `x` and `y` are two integer variables whose values are 13 and 5 respectively
  - `x+y :  18`
  - `x-y :  8`
  - `x*y :  65`
  - `x/y :`

Example

- Suppose `x` and `y` are two integer variables whose values are 13 and 5 respectively
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  - `x/y : 2`

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  - `x-y : 8`
  - `x*y : 65`
  - `x/y : 2`
  - `x%y : 3`

- **Note**
  - All operators except % can be used with operands of all of the data types int, float, double, char (yes! char also! We will see what it means later)
  - % can be used only with integer operands

Operator precedence

- In decreasing order of priority
  1. Parenthesis
  2. Unary minus (-5)
  3. Multiplication, division and modulus (`x*y : 65`)
  4. Addition and subtraction
- For operators of the same priority, evaluation is from left to right
- Parenthesis may be used to change the precedence of operator evaluation

Examples of arithmetic expressions

```
a+b*c-d/e
```

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f`

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`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

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`a-b+c-d`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f` $\rightarrow$ `a*(-b)+(d%e)-f`

`a-b+c-d` $\rightarrow$ `(((a-b)+c)+d)`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f` $\rightarrow$ `a*(-b)+(d%e)-f`

`a-b+c-d` $\rightarrow$ `(((a-b)+c)+d)`

`x*y*z`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f` $\rightarrow$ `a*(-b)+(d%e)-f`

`a-b+c-d` $\rightarrow$ `(((a-b)+c)+d)`

`x*y*z` $\rightarrow$ `((x*y)*z)`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f` $\rightarrow$ `a*(-b)+(d%e)-f`

`a-b+c-d` $\rightarrow$ `(((a-b)+c)+d)`

`x*y*z` $\rightarrow$ `((x*y)*z)`

`a+b+c*d*e`

Examples of arithmetic expressions

`a+b*c-d/e` $\rightarrow$ `a+(b*c)-(d/e)`

`a*-b+d%e-f` $\rightarrow$ `a*(-b)+(d%e)-f`

`a-b+c-d` $\rightarrow$ `(((a-b)+c)+d)`

`x*y*z` $\rightarrow$ `((x*y)*z)`

`a+b+c*d*e` $\rightarrow$ `(a+b)+((c*d)*e)`

Type of value of expression

- If all operands of an operator are integer (int variable or integer constants), the value is always integer
  - Example: 9/5 will be 1 not 1.8
  - Example:

```
int a=9,b=5;
printf("%d",a/b);
```

- If at least one operand is real, the value is real
  - **Caution:** Since floating-point values are rounded to the number of significant digits permissible, the final value is an approximation of the final result
  - Example: 1/ 3.0 * 3.0 may have the value 0.99999 and not 1.0
  - So checking if 1/ 3.0 * 3.0 is equal to 1.0 may return **false!!**
- The type of the final value of the expression can be found by applying these rules again and again as the expression is evaluated following operator precedence

Issues

```
int a=10,b=4,c;
float x;
c=a/b;
x=a/b;
```

- Value of c will be 2
- Value of x will be 2.0
- Want 2.5 to be stored in x

Assignment expression

- Uses the assignment operator '='
- General syntax:

```
variable_name = expression
```

- Left of = is called l-value, must be a modifiable variable
- Right of = is called r-value, can be any expression
- Examples:
  - `velocity = 20`
  - `b = 15; temp = 12.5`
  - `A = A + 10`
  - `v = u + f * t`
  - `s = u * t + 0.5 * f * t * t`

Assignment expression (contd.)

- An assignment expression evaluates to a value same as any other expression
- Value of an assignment expression is the value assigned to the l-value
- Example: value of
  - `a = 3` is 3
  - `b = 2*4 - 6` is 2
  - `n = 2*u + 3*v - w` is whatever the arithmetic expression 2*u + 3*v - w evaluates to given the current values stored in variables u, v, w
- Several variables can be assigned the same value using multiple assignment operators

```
a = b = c = 5;
flag1 = flag2 = 'y';
speed = flow = 0.0;
```

- Easy to understand if you remember that
  - The assignment expression has a value
  - Multiple assignment operators are right-to-left associative

Example

- Consider a= b = c = 5
  - Three assignment operators
  - Rightmost assignment expression is c=5, evaluates to value 5
  - Now you have a = b = 5
  - Rightmost assignment expression is b=5, evaluates to value 5
  - Now you have a = 5
  - Evaluates to value 5
  - So all three variables store 5, the final value the assignment expression evaluates to is 5

Types of l-value and r-value

- Usually should be the same
- If not, the type of the r-value will be internally converted to the type of the l-value, and then assigned to it
- Example:

```
double a;
a = 2*3;
```

  - Type of r-value is int and the value is 6
  - Type of l-value is double, so stores 6.0

Type mismatch

```
int a;
a = 2*3.2;
```

- Type of r-value is float/double and the value is 6.4
- Type of l-value is int, so internally converted to 6
- So a stores 6, not the correct result
- But an int cannot store fractional part anyway
- So just badly written program
- Be careful about the types on both sides

More assignment operators

- +=, -=, *=, /=, %=
- Operators for special type of assignments
- a += b is the same as a = a + b
- Same for -=, *=, /=, and %=
- Exact same rules apply for multiple assignment operators

Example

- Suppose x and y are two integer variables whose values are 5 and 10 respectively

`x += y`	Stores 15 in x	Evaluates to 15
`x -= y`	Stores -5 in x	Evaluates to -5
`x *= y`	Stores 50 in x	Evaluates to 50
`x /= y`	Stores 0 in x	Evaluates to 0

Logical expression

- Uses relational and logical operators in addition
- Informally, specifies a condition which can be true or false
- Evaluates to value 0 or 1
  - 0 implies the condition is false
  - 1 implies the condition is true
- Examples:

```
(count <= 100)
((math+phys+chem)/3 >= 60)
((sex == 'M') && (age >= 21))
((marks >= 80) && (marks < 90))
((balance > 5000) || (no_of_trans > 25))
(!(grade == 'A'))
```

Relational operators

- Used to compare two quantities
  - `<` is less than
  - `>` is greater than
  - `<=` is less than or equal to
  - `>=` is greater than or equal to
  - `==` is equal to
  - `!=` is not equal to

Examples

$10 > 20$ — is false, so value is 0

$25 < 35.5$ — is true, so value is 1

$12 > (7 + 5)$ — is false, so value is 0

$32 \; != 21$ — is true, so value is 1

- When arithmetic expressions are used on either side of a relational operator, the arithmetic expressions will be evaluated first and then the results compared

  `a + b > c - d` is the same as `(a+b) > (c+d)`

Logical operator

- Logical AND (**&&**)
  - Evaluates to 1 if both the operands are non-zero
- Logical OR (||)
  - Results is true is at least one of the operand is non-zero

X	Y	X&&Y	X||Y
0	0	0	0
0	non-0	0	non-0
non-0	0	0	non-0
non-0	non-0	non-0	non-0

Logical operator (contd.)

- Unary negation operator (!)
  - Single operand
  - Value is 0 if operand is non-zero
  - Value is 1 if operand is 0

Example

- `(4 > 3) && (100 != 200)`
  - 4 > 3 is true, so value 1
  - 100 != 200 is true so value 1
  - Both operands 1 for &&, so final value 1
- (!10) && (10 + 20 != 200)
  - 10 is non-0, so value !10 is 0
  - 10 + 20 != 200 is true so value 1
  - Both operands NOT 1 for &&, so final value 0
- (!10) || (10 + 20 != 200)
  - Same as above, but at least one value non-0, so final value 1

Example (contd.)

- a = 3 && b = 4
  - No parenthesis, so need to look at precedence and associativity
  - = has higher precedence than &&
  - b=4 is an assignment expression, evaluates to 4
  - a = 3 is an assignment expression, evaluates to 3
  - Both operands of && are non-0, so final value of the logical expression is 1
- Note that changing to b = 0 would have made the final value 0

Example

```
void main () {
  int i, j;
  scanf("%d%d",&i,&j);
  printf ("%d AND %d = %d, %d OR %d=%d\n", i,j,i&&j, i,j, i||j) ;
}
```

- If 3 and 0 are entered from keyboard, output will be 3 AND 0 = 0, 3 OR 0 = 1

Special operator: AddressOf (&)

- Remember that each variable is stored at a location with an unique address
- Putting & before a variable name gives the address of the variable (where it is stored, not the value)
- Can be put before any variable (with no blank in between)

```
int a =10;
printf("Value of a is %d, and address of a is %d\n", a, &a);
```

Recall earlier issues

```
int a=10,b=4,c;
float x;
c=a/b;
x=a/b;
```

- Value of c will be 2
- Value of x will be 2.0
- Want 2.5 to be stored in x

Solution: Typecasting

- Changing the type of a variable during its use
- General form

```
(type_name) variable_name
```

- Example

```
x = ((float) a)/ b;
```

- Now x will store 2.5 (type of a is considered to be float for this operation only, now it is a mixed-mode expression, so real values are generated)

Typecasting

- Not everything can be typecast to anything
  - float/double should not be typecast to int (as an int cannot store everything a float/double can store)
  - int should not be typecast to char (same reason)
- General rule: make sure the final type can store any value of the initial type

Example

```
int a,b;
float avg;
scanf("%d%d",&a,&b);
avg=(a+b)/2;
printf("%f\n",avg);
```

Wrong

```
int a,b;
float avg;
scanf("%d%d",&a,&b);
avg=((float)(a+b)/2);
printf("%f\n",avg);
```

```
int a,b;
float avg;
scanf("%d%d",&a,&b);
avg=(a+b)/2.0;
printf("%f\n",avg);
```

More operators

- Increment (++), Decrement (−−)
  - Both of these are unary operators; they operate on a single operand
  - The increment operator causes its operand to be increased by 1
    - Example: a++, ++count
  - The decrement operator causes its operand to be decreased by 1.
    - Example: i--, --distance

Pre vs Post increment

- Operator written before the operand (`++i, --i`)
  - Called pre-increment operator (also sometimes called prefix ++ and prefix --)
  - Operand will be altered in value before it is utilized in the program
- Operator written after the operand (`i++, i--`)
  - Called post-increment operator (also sometimes called postfix ++ and postfix --)
  - Operand will be altered in value after it is utilized in the program

Examples

- Initial values: `a = 10; b = 20;`

`x = 50 + ++a;`	`a = 11, x = 61`
`x = 50 + a++;`	`a = 11, x = 60`
`x = a++ + --b;`	`a = 11, b=19, x = 29`
`x = a++ + ++a;`	??

Called **side effects** (while calculating some values, something else gets changed)