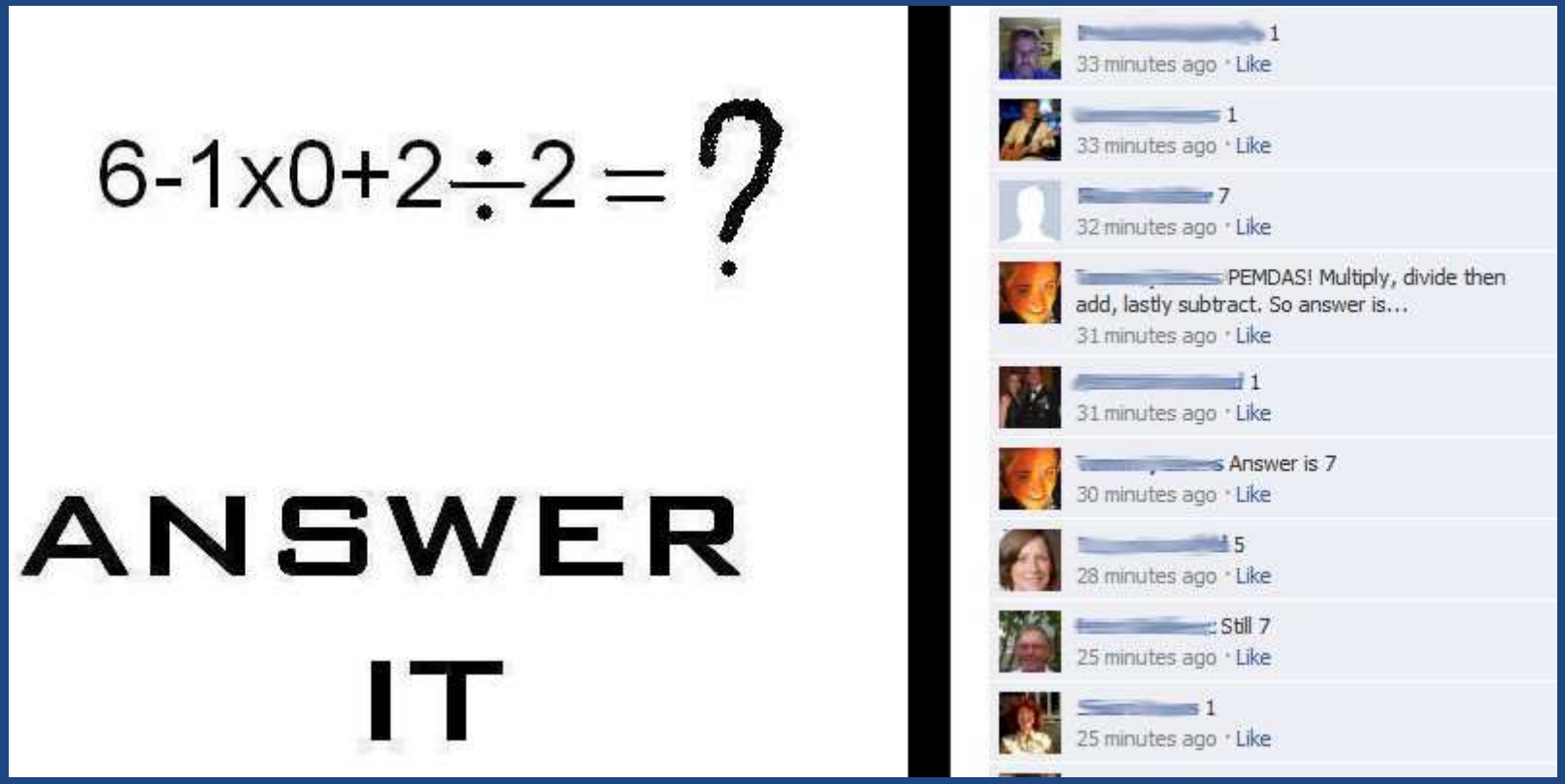
Expressions

Chapter 2.3 (part)

Slides #4



Topics

1) How can we calculate values?
2) How to work with constants like 24 hours-per-day?
3) How high (low?) can we count?

Math Expressions

(And not like "Wow! Math is great!")

Expressions

- Expression:
  - A statement that...
  - Usually has an operator.
- Examples:

```
result = 3;
result = 1 * x + 2;
```

- Expressions usable anywhere a value is needed:
  - println("Big number {}", 1 + 2);

Order of Operations

- What is the value of result?

  int result = 4 + 10 / 2;

  - Is it 7 or 9? (4 + 10) / 2 or 4 + (10 / 2)
- Each operator is given a precedence:
  - Higher precedence operators are applied first.
  - / is higher than +, so the answer is..
  - Add brackets to force an ordering.
- Associativity:
  - Apply the operators from right-to-left, or left-to-right?
  - +, - are left to right: do the one on the..
  - =, += are right to left: do the one on the..

Operator precedence

- Operators at same..

  evaluated based on associativity.
  - * and / from L to R
  - = and += from R to L
- Examples:
  - result = -20 + 9 / 5;
  - result = (-20 + 9) / 5;
  - val = 6 + 5 * 4 / 3 * 2;
  - sum = sum + 10;

Prec. Level	Op.	Operation	Associates
1	[ ]	Array Index	L to R
2	+ -	unary plus unary minus	R to L
3	* / %	mult, div, remainder	L to R
4	+ -	add subtract	L to R
5	<< >>	stream ins. extract.	L to R
6	< <= > >=	comparisons	L to R
7	= += -= *= ...	assignments	R to L

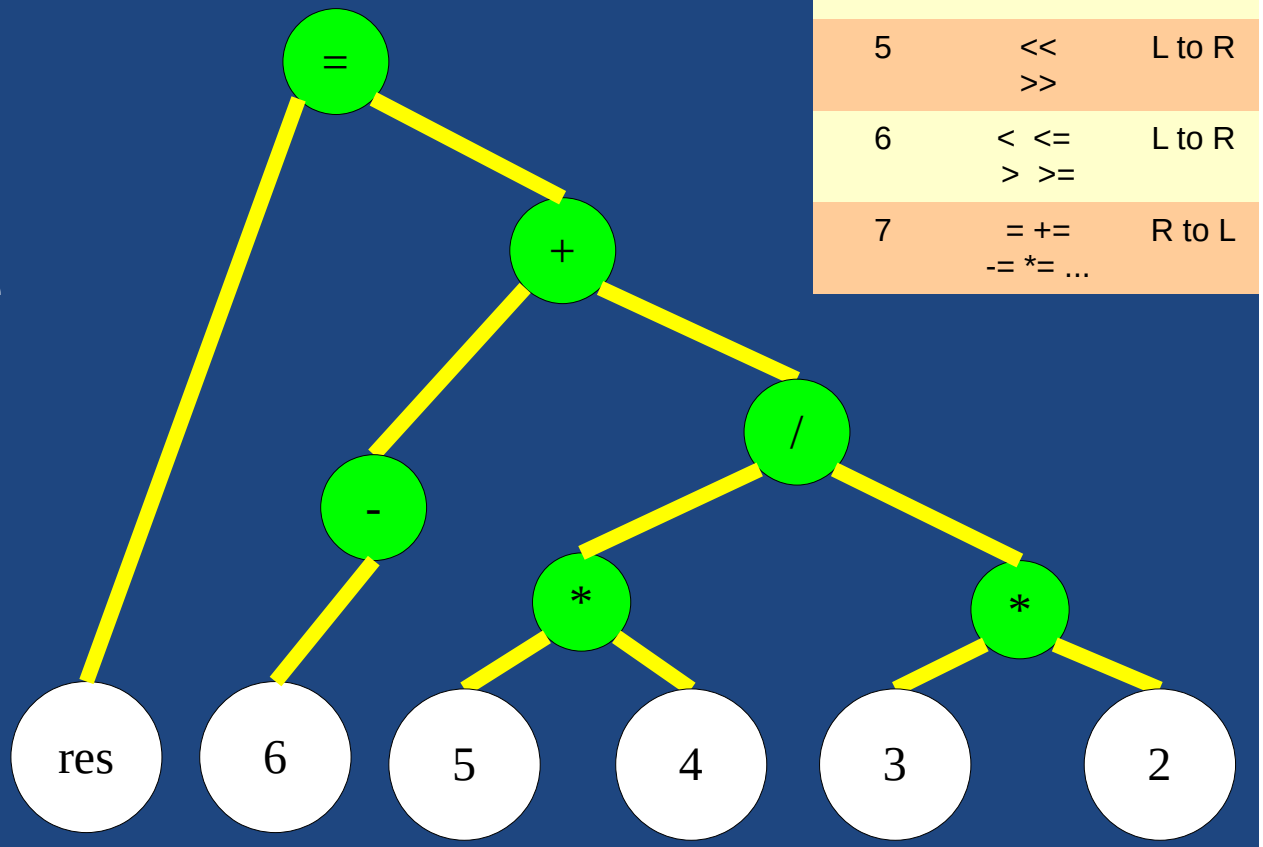
Order can be forced by parentheses.
See text Appendix 2 for full table.

Brackets

- A statement can be correct, but unreadable:
  - result = 1 + 2 / 6 - 1 * 3 / 4 - 3 - -3 * +4;
- Add brackets to make it clear:
  - result = 1 + (2 / 6) - (1 * 3 / 4) - 3 - (-3 * (+4));

Expression tree

- Represent res = -6 + 5 * 4 / (3 * 2) as a tree:
- Operands as leaves.
- Operators as branching nodes.
- Operations lower in the tree have..
- Evaluate from the..
- Write values on internal nodes.



Prec. Level	Op.	Asso.
1	[ ]	L to R
2	unary + unary -	R to L
3	* / %	L to R
4	+ -	L to R
5	<< >>	L to R
6	< <= > >=	L to R
7	= += -= *= ...	R to L

Review

- Draw an expression tree for the following:

  answer = 5 * x + 6 * (1 – x);

Assume x=2

Prec. Level	Op.	Asso.
1	[ ]	L to R
2	unary + unary -	R to L
3	* / %	L to R
4	+ -	L to R
5	<< >>	L to R
6	< <= > >=	L to R
7	= += -= *= ...	R to L

Constants

Constants

- We have already used literal constants:

```
int x = 10;                    // Numeric constant
println("Hello world!");       // String literal
```

- Raw number in code are..

```
int w = d / 7;
int c = s / 72;
```

- Prefer named constants over magic numbers:

```
const int MIN_PER_HOUR = 60;
int h = m / MIN_PER_HOUR;
```

const

- const qualifier makes a variable..

```
const double PAY_PER_DAY = 475.50;
const int DAYS_PER_WEEK {7};
```

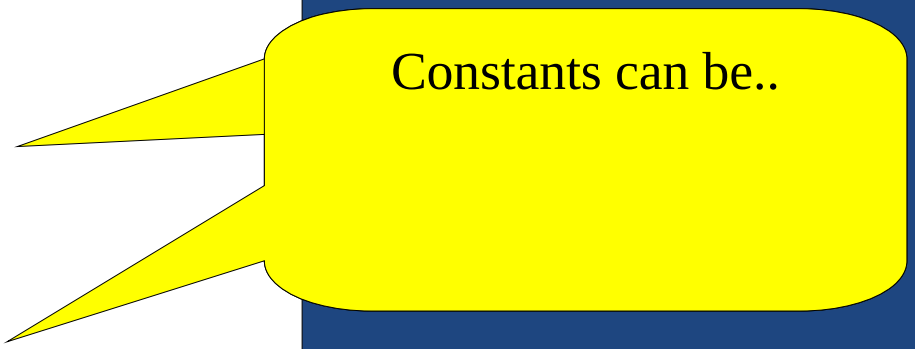
  - Constants must be given a value when created.
  - Name is upper case by..
  - Program cannot modify value of a constant:

```
PAY_PER_DAY = 99.9; // ERROR!
```

- Advantages:
  - Program becomes more...
  - Can change value in entire program in one spot.
    - Ex: change tax rate that's used in 100 calculations!

Example with const

```
// Convert days to weeks/years/fortnights.
#include <iostream>
#include <print>
using namespace std;

const int DAYS_PER_WEEK = 7;
const int DAYS_PER_YEAR = 365;

int main()
{
    const int DAYS_PER_FORTNIGHT = 14;

    println("Enter the number of days: ");
    int numDays = 0;
    cin >> numDays;

    int numWeeks = numDays / DAYS_PER_WEEK;
    int numYears = numDays / DAYS_PER_YEAR;
    int numFortnight = numDays / DAYS_PER_FORTNIGHT;

    println("# Days:       {:4}", numDays);
    println("# Weeks:      {:4}", numWeeks);
    println("# Years:      {:4}", numYears);
    println("# Fortnights: {:4}", numFortnight);
}
```




```
Enter the number of days:
4641
# Days:       4641
# Weeks:       663
# Years:        12
# Fortnights:  331
```

Guide to Constants

- Which of the following literal constants would be best made into named constants?
  - int numStudents = 0;
  - int next = numStudents + 1;
  - int waitlist = numStudents – 72;

Combined Assignments & Overflow

Assignment Operators

- Combine an operation with assignment:
  - +=, -=, *=, /=, %=
- Examples:
  - a += b;
    // means a = a + b;
  - a *= b;
    // means a = a * b;
  - a /= 2 + 3;
    // means...

```
// Sum of numbers from 0 to MAX_COUNT
#include <print>
using namespace std;

const int MAX_COUNT {10};
int main()
{
    // Initialize the accumulator
    int sum {0};

    // Loop through 0 to MAX_COUNT - 1
    int i {0};
    while (i < MAX_COUNT) {
        sum += i;
        i++;
    }
    println("Sum from 0 to {} = {}",
        MAX_COUNT - 1, sum);
}
```

```
Sum from 0 to 9 = 45
```

Overflow & Underflow

- Each type has a maximum value it can store.

```
// Work with overflow/underflow
#include <print>
#include <climits>
using namespace std;

int main() {
    int test = INT_MAX;

    println("Start at:      {:12}", test);
    test += 1;
    println("Adding 1:      {:12}", test);
    test -= 1;
    println("Subtracting 1: {:12}", test);
}
```

#include <climits>..

..

INT_MIN, INT_MAX,
CHAR_MIN, CHAR_MAX,
....

```
Start at:          2147483647
Adding 1:         -2147483648
Subtracting 1:     2147483647
```

  - Maximum + 1 overflows to the minimum.
  - Minimum – 1 underflows to the maximum.

Suggested Review Questions

- Draw an expression tree for the following:
  result = 8 * - 1 + 3 / 2
  - Solve it by writing values on the nodes.
  - Write a C++ program to double check your answer.

Summary

- Expressions calculate values using operators.
  - Operator precedence gives us expression trees.
- Use named constants (const), not magic numbers.
- Combined assignment operators like x += 2;