



Assignment 2: Solving equations

In this assignment you will use linked lists to recognize and solve equations.

Not all equations are easily solvable, therefore we restrict ourselves to linear equations, such as $3x + 4 = 2 - x$, $-8x + 1 = 0$ and $x = 3x + 1$. For further simplification we require that the equations do not contain parentheses, so e.g. $4(x + 1) = 3$ is excluded. Moreover, we only solve linear equations in one variable, not e.g. $x + y + 3 = x - 5$.

The assignment has two parts and both should be submitted on Themis. The deadline for part 2 is one week later.

Part 1: recognizing and classifying the equation

First you have to write a recognizer that should recognize equations.

Grammar

The equations to be recognized in this assignment are generated by the following grammar:

$\langle \text{equation} \rangle ::= \langle \text{expression} \rangle '=' \langle \text{expression} \rangle .$

$\langle \text{expression} \rangle ::= ['-'] \langle \text{term} \rangle \{ '+' \langle \text{term} \rangle \mid '-' \langle \text{term} \rangle \} .$

$\langle \text{term} \rangle ::= \langle \text{nat} \rangle \mid [\langle \text{nat} \rangle \langle \text{identifier} \rangle ['^' \langle \text{nat} \rangle] .$

Here $\langle \text{nat} \rangle$ is a non-negative number as defined in Section 1.4.2 of the Lecture notes.

You may use the functions described in sections 1.4.4 (Scanning) and 1.4.5 (Recognition) of the Lecture notes. They are available on Themis.



Alert!

Here we only want a special kind of expressions, defined by the line for $\langle \text{expression} \rangle$ above. This differs from the expressions used in Section 1.4 of the Lecture notes and by the function `acceptExpression` in the file `recognizeExp.c`.



Tip

You should thus copy `recognizeExp.c` to `recognizeEq.c` and adapt it to the grammar above. Hint: You need to change function `acceptExpression` and `acceptTerm`. The functions `acceptNumber`, `acceptIdentifier` and `acceptCharacter` do *not* have to be changed.

Your Task

Your program should not solve all equations generated by this grammar. In this first part your program should check

- whether the input is an equation, i.e. a production of $\langle \text{equation} \rangle$;
- if so, whether it is an equation in one variable;
- if so, what its degree is.

The communication with your program should run via a dialogue, as with the evaluation of arithmetical expressions in Section 1.4.5 and 1.4.6 of the Lecture notes.

Input and Output Example

input	corresponding output
$3 + x - 3x = -x^2 - 3x^3$ $2x^1 - 4x^0 = 7$ $x + y = 0$ $2 \text{ longvariablename} = 6$ $x^2 + 5x - 7$ $2x = 3 = 4y$ $= 3x + 7$ $x^2 + x == 3$ $x (x + 3) = 7$ $!$	<p>give an equation: $3 + x - 3x = -x^2 - 3x^3$ this is an equation in 1 variable of degree 3</p> <p>give an equation: $2x^1 - 4x^0 = 7$ this is an equation in 1 variable of degree 1</p> <p>give an equation: $x + y = 0$ this is an equation, but not in 1 variable</p> <p>give an equation: $2 \text{ longvariablename} = 6$ this is an equation in 1 variable of degree 1</p> <p>give an equation: this is not an equation</p> <p>give an equation: $x^2 + 5x - 7$ this is not an equation</p> <p>give an equation: $2x = 3 = 4y$ this is not an equation</p> <p>give an equation: $= 3x + 7$ this is not an equation</p> <p>give an equation: $x^2 + x == 3$ this is not an equation</p> <p>give an equation: $x (x + 3) = 7$ this is not an equation</p> <p>give an equation: good bye</p>

Themis

The following two files will be inserted by Themis automatically — you do not need to re-upload them and you should not have any conflicting definitions in your own files:

- scanner.c
- scanner.h

You could for example structure your solution into three files:

- recognizeEq.h (based on recognizeExp.h)
- recognizeEq.c (based on recognizeExp.c)
- mainRecogEq.c (based on mainEvalExp.c)

Part 2: solving the equations

Now extend the program for Part 1 by giving the solution in the case that it is an equation of one variable of degree 1. Print the answer, rounded to 3 decimals. When the equation is not solvable (i.e. there are no solutions, or infinitely many), you print: `not solvable`.



Tip

When applied to expressions of type `int`, the C operator `/` performs *integer division*, so e.g. `1/3 == 0`. To do a normal division you should cast one of the input expressions into a floating point number type. For example, instead of `'1/3'` you can write `'1 / (double) 3'`. See also the lecture notes of *Imperative Programming*, section 2.6.4.



Tip

When printing real numbers with e.g. 3 decimals, C will print `-0.000` for numbers between `-0.0005` and `0`. To prevent this, converts these values to `0` before printing.

Input and Output example

input	corresponding output
<code>x - 34 = - 15x + 14</code>	give an equation: <code>x - 34 = - 15 x + 14</code>
<code>4y + 1 = y</code>	this is an equation in 1 variable of degree 1
<code>10000z = -1</code>	solution: 3.000
<code>x^2 = 4</code>	
<code>5x - 7</code>	give an equation: <code>4 y + 1 = y</code>
<code>2x = 3 = 4y</code>	this is an equation in 1 variable of degree 1
<code>= 3x + 7</code>	solution: -0.333
<code>!</code>	
	give an equation: <code>10000 z = - 1</code>
	this is an equation in 1 variable of degree 1
	solution: 0.000
	give an equation: <code>x ^ 2 = 4</code>
	this is an equation in 1 variable of degree 2
	give an equation: <code>5 x - 7</code>
	this is not an equation
	give an equation: <code>2 x = 3 = 4 y</code>
	this is not an equation
	give an equation: <code>= 3 x + 7</code>
	this is not an equation
	give an equation: good bye

The same two files as for part 1 will be included by Themis automatically.

Extra (up to 2 bonus points)

- Extend your solver to equations of degree 2:

input	corresponding output
x ² = 4	give an equation: $x^2 = 4$
2 long ² - 4long ¹ = 7	this is an equation in 1 variable of degree 2
10 x ² - 10 = -10	solution: 2.000 and -2.000
two ² - 2 = 2 =	
y ² + x ² = 5 x	give an equation: $2 \text{ long}^2 - 4 \text{ long}^1 = 7$
25y + 12 = y	this is an equation in 1 variable of degree 2
!	solution: 3.121 and -1.121
	give an equation: $10 x^2 - 10 = -10$
	this is an equation in 1 variable of degree 2
	solution: 0.000
	give an equation: $\text{two}^2 - 2 = 2 =$
	this is not an equation
	give an equation: $y^2 + x^2 = 5 x$
	this is an equation, but not in 1 variable
	give an equation: $25 y + 12 = y$
	this is an equation in 1 variable of degree 1
	solution: -0.500
	give an equation: good bye

- Extend your recognizer and solver to pairs of linear equations with two variables:

input	corresponding output
3x + y = 4	give an equation: $3 x + y = 4$
6y = 4 - 4x	give an equation: $6 y = 4 - 4 x$
27=2apples+14bananas-11	solution: $x = 1.429$ and $y = -0.286$
- apples = 3 bananas - 11	
x = 10	give an equation: $27 = 2 \text{ apples} + 14 \text{ bananas} - 11$
a + x = 100	give an equation: $-\text{apples} = 3 \text{ bananas} - 11$
7a + 7b - 5a = 5a - 3a	solution: $\text{apples} = 5.000$ and $\text{bananas} = 2.000$
23b - 5a = 22a - 27a	
!	give an equation: $x = 10$
	give an equation: $a + x = 100$
	solution: $x = 10.000$ and $a = 90.000$
	give an equation: $7 a + 7 b - 5 a = 5 a - 3 a$
	give an equation: $23 b - 5 a = 22 a - 27 a$
	not solvable
	give an equation: good bye