Surnames: _____ *Name:* _____

Exercise 1 *[5.5 points]*

A basic calculator performs arithmetic operations of addition, subtraction, multiplication and division with real numbers, which are received digit by digit. The operator only performs operations in the form $value\ op\ number$, where $value$ is the current value in the calculator and op and $number$, are the last arithmetic operator and number that have been received in the calculator respectively. It allows to evaluate specific arithmetic expressions, for example: $(2{,}2 - 3) * 2 + 1$. For this purpose, it has the following events which are subjected to some restrictions as follows:

Event	*Specification*
$digit(ch)$	Receives the next numeric character (a digit) of the number which is received digit by digit in the calculator. No restrictions.
$point()$	Set a decimal point to the $number$ which is being received digit by digit. Therefore, the following digits will form the decimal part. If before receiving this event, a digit has not been sent yet, then the integer part of the number is set to 0. Moreover, this event can be sent only once for every number that the calculator receives.
$operator(ch)$	The calculator receives an arithmetic operator, one of the following characters: $+$, $-$, $*$ or $/$. Only if the calculator has received a number *(dígit by dígit) or an expression has been evaluated.*
$result()$[1]	Get the value of the arithmetic expression. Only if the calculator has received a number (digit by digit) or an expression has been evaluated. In the second case, if $value$ is the result of an expression already evaluated, then it evaluates the expression: value op number, where op and number are the last arithmetic operator which has been received in the calculator, and the last received number digit by digit in it, respectively.

Do the following tasks:

Do a graph and a states table (table graph) of the calculator. *[4.5 pts. + 1 pt.]*

[1] Take into account that the event $result()$ not always evaluates a new expression, and in consequence the value of the calculator has to be set to 0. The $value$ of the calculator (the evaluation result) is required in the following situations:

- When this event is launched several times in a row: this is allowed and has the consequences that are written in the specification.
- When after launching this event the calculator receives an operator op, then $value$ is the first operand of this. The second operand is another number received in the calculator, and can take part of any arithmetic expression.

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Exercise 2. Next *[4.5 pts.]*

States Table of the calculator and states description

Event	State			
	0	1	2	3
$digit(ch)$	1	1	2	1
$point()$	2	2	ANA	2
$operator(ch)$	ANA	0	0	0
$result()$	ANA	3	3	3
$reset()$	0	0	0	0
$display()$	0	1	2	3

State	*Description*
0	The calculator receives an operator
1	The calculator receives a number digit by digit
2	Decimal point received. Digits received after are in the decimal part
3	State where the value of an expression is calculated

Given the above states table, where the additional events $reset()$ and $display()$ have been included, and that are specified below and the following additional features for the calculator:

- It has a data type of string of characters (*string*), named $display$, where the content is one out of the following two:
  a. Characters that correspond to the value of the last arithmetic operation performed. This string of characters will remain while a new number is not provided to the calculator or a new evaluation is performed.
  b. Characters from the last number being received by the calculator digit by digit (including the decimal point if it has one). The string of characters will be kept until an arithmetic operation is performed or the reception of a new number starts.
- Initially, the internal value of the calculator is 0, and this value will come up again in the following cases:
  - When an expression is evaluated through the event $result()$, before the calculator receives a new number (digit by digit).
  - When the $reset()$ event is launched.
  - When the result of an expression evaluation is 0.

Do the following tasks:

1. Provide the data state and its initial value. *[0.25 ptos.]*
2. Provide the actions table for the data state in the former section. If a condition is required to change any datum, or some alternatives happen, use conditinal expression with the form: *[2.25 ptos.]*

   if $condition$ **then** A | **if** $condition$ **then** A **else** B
3. Provide a sequence of events that, finally, returns a string of characters which comes from the evaluation of the expression: $(2{,}1 + 3)/2 - 5{,}75 + 0{,}2 + 0{,}2 + 0{,}2 - 1$where its result is $-3{,}6$. *[0.75 ptos.]*
4. Provide the trace for the given sequence of events from the previous section. The trace has to be done according to given answers in the first two sections, otherwise it will not be consider as valid. *[1.25 ptos.]*

Event	*Specification*
$reset()$	Set the calculator in the initial conditions to evaluate the arithmetic expression which is provided. *No constraints*.
$display()$	Return the string of characters $display$. No *constraints*.

Note: Observe that with the given specification for the event $result()$, the required sequence of events to evaluate an arithmetic expression containing repeated consecutive terms can be simplified. For example, the expression $2{,}5 + 2 + 2$ contains the addition $+\,2$ twice and consecutively, so it can be evaluated with the sequence of events: $digit('2')$, $point()$, $digit('5')$, $operator('+')$, $digit('2')$, $result()$ and $result()$, instead of using the sequence of events: $digit('2')$, $point()$, $digit('5')$, $operator('+')$, $digit('2')$, $operator('+')$, $digit('2')$, $result()$. The first sequence, when the $result()$ event is launched first, the value of the expression $2{,}5 + 2$ is obstained, providing the $value$ $4{,}5$. Then, when the $result()$ event is launched consecutively, the value of the expression is $4{,}5 + 2$, because the last received operator in the calculator was $'+'$, and the last received digit (dígit by dígit) was 2.