Formal Languages and Compilers
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Written exam[1]: laboratory question
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The laboratory question must be answered taking into account the implementation of the Acse compiler given with the exam text.

Modify the specification of the lexical analyser (flex input) and the syntactic analyser (bison input) and any other source file required to extend the Lance language with the vcmp operator. The vcmp operator performs the element-wise comparison of arrays, storing the result in a third array. Two source arrays x and y are compared, and the result is stored in a destination array z, using the syntax: `z = vcmp(x, y)`. If the n-th element of the first source array is greater than the n-th element of the second source array, the n-th element of the destination array will have a value of 1. Conversely if the n-th element of the second array is greater than the corresponding element in the first array, the destination array is loaded with a value of -1. If two corresponding elements of the source arrays are equal, the corresponding element in the destination array should acquire a value of 0. Application of the operator on arrays of different sizes or on scalars should result in a compilation error.

The following excerpt of code exemplifies the use of the operator.

```
int x[3];
int y[3];
int z[3];

x[0] = 0;
x[1] = 4;
x[2] = -3;

y[0] = 0;
y[1] = 2;
y[2] = 1;

z = vcmp(x, y);

write(z[0]); /* Writes 0 */
write(z[1]); /* Writes 1 */
write(z[2]); /* Writes -1 */
```

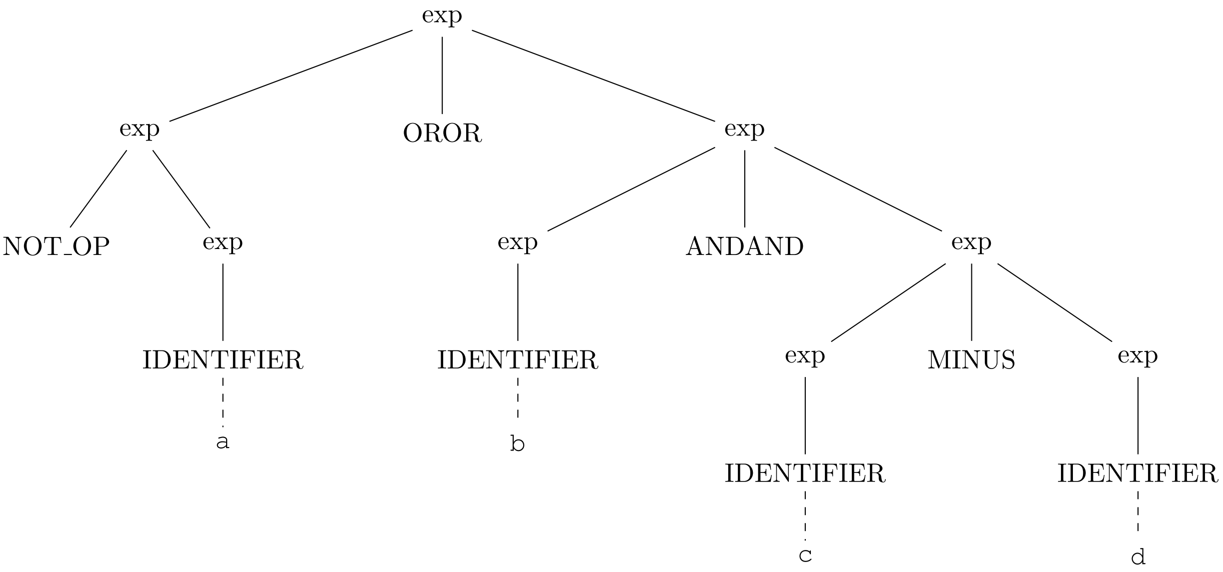
[1] Time 60'. Textbooks and notes can be used.
Pencil writing is allowed. Write your name on any additional sheet.

1. Define the tokens (and the related declarations in **Acse.lex** and **Acse.y**). (1 points)
2. Define the syntactic rules or the modifications required to the existing ones. (2 points)
3. Define the semantic actions needed to implement the required functionality. (22 points) The solution is in the attached patch.

4. Given the following `Lance` code snippet:

```
! a || b && c - d
```

write down the syntactic tree generated during the parsing with the Bison grammar described in Acse.y *starting from the* `exp` *nonterminal.* (5 points)



5. (**Bonus**) Discuss how you would implement the `vcmp` operator if it could mix vectors and scalars, describing a suitable semantic and implementation.