

COL226: Programming Languages

Mon 11, Apr 2022

MajorQ2

5+15 (+5 for PwD) minutes

Max marks 15

Instructions:

1. Download the paper and write your name and entry number in the designated space on top and *do not forget to sign the honour statement below.*
2. Answer the question(s). *Answers will be judged for correctness, efficiency and elegance.*
4. If there are minor mistakes in the question, correct them explicitly and answer the question accordingly. If the question is totally wrong, give adequate reasons why it is wrong with detailed counter-examples, if necessary.
4. Scan the paper with your completed answer.
5. Upload it on Gradescope 2102-COL226 page within the given time. *Make sure the first page with your name, entry no and signature is also the first page of your uploaded file*
6. Late submissions (within 2 minutes of submission deadline) on the portal will attract a penalty of 10% of the total marks allotted to the paper for each minute of delay and 20% for each minute of delay thereafter.
7. Email submissions after the closing of the portal will not be evaluated (You get a 0).
8. Uploads without the first page details (including signature) may be awarded 0 marks.

I abide by the Honour code that I have signed on my admission to IIT Delhi. I have neither given any help to anybody nor received any help from anybody nor from any site or other sources in solving the question(s) in this paper.

Signature:**Date:****[15 marks]**

Let `sin`, `cos`, `exp` (exponentiation e^x), `ln` (natural logarithm) besides `plus`, `minus`, `mult`, `quot` (real division) be constructors of a language of expressions over numbers, with their usual arities and their usual meanings. We then compute derivatives “symbolically” as follows.

Let `deriv(E, X, DE)` denote that the symbolic derivative of expression `E` with respect to variable `X` is the expression `DE`. Given the following facts (in order)

```
deriv(N, X, 0) :- number(N), var(X).  
deriv(X, X, 1) :- var(X).
```

Complete the Prolog program to compute symbolic derivatives of any expression in the language of expressions.

In particular make sure your definitions can calculate the derivatives of complicated expressions that may occur in any course on calculus (such as for example $3 * \exp(5 * X) * \sin(2 * X) + \cos(X)/\ln(X)$).

Hint: This question is merely meant to test your basic understanding of the bare essentials of Prolog. It will require a lot more refinement than even your “correct” answer to get it to actually work in Prolog!