Auto-Differentiation

1. Draw the expression graph for the expression

$$f = \left(y^2 + x\right) \ln(x)$$

   and use the graph to compute $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$.

2. Download the notebook `ex04_ad.ipynb`. You will also need the module `ad.py`. Familiarize yourself with the code in `ad.py`, and see how it reflects the design outlined in video lectures.

   (a) Run the notebook, block-by-block, and make sure you understand what it is doing. Feel free to add your own code to the notebook to try things out.

   (b) Create your own operation using the template in the notebook. You have to implement its application, as well as its derivative.

   (c) Try creating your own expression, and encode it using the AD code. Choose an expression that has a local optimum.

   (d) Try finding the local optimum of your expression using the gradient-based method. You might have to adjust the initial guess, the step size, and the number of iterations.

3. Download the notebook `ex04_matad.ipynb`. You will also need the module `matad.py`; it defines a `Mat` class for holding matrix variables (and their gradients), as well as a `MatOperation` class, the abstract base class for operations on `Mat` objects.

   Note that the `MatOperation` for multiplication, `Mul`, as well as its wrapper, `mul`, are not implemented in `matad.py`. That's part of your assignment.

   You can look inside `matad.py` to see how those classes are implemented. Run the notebook to become familiar with using the matrix AD functions.