

## E.1 Python Exercise

Write a Python script to implement the backpropagation algorithm for a  $1 - S^1 - 1$  network. Write the program using matrix operations, as in Eq. (11.41) to Eq. (11.47). Choose the initial weights and biases to be random numbers uniformly distributed between -0.5 and 0.5 (using the function `rand`), and train the network to approximate the function

$$g(p) = e^{-abs(p)} \times \sin(\pi p) \text{ for } -2 \leq p \leq 2$$

Use  $S^1 = 2$  and  $S^1 = 10$ . Experiment with several different values for the learning rate  $\alpha$ , and use several different initial conditions. Discuss the convergence properties of the algorithm as the learning rate changes.

Plot the trained networks with the network outputs. Compare them. Check the squared error for each epochs.

You do not need to use any ML packages, you are allowed to use basic python packages. Please code the summary of backprop equations (that is the only thing you need).

### **Bonus points:**

Write your code in a format that you can enter any number of neurons in hidden layer.