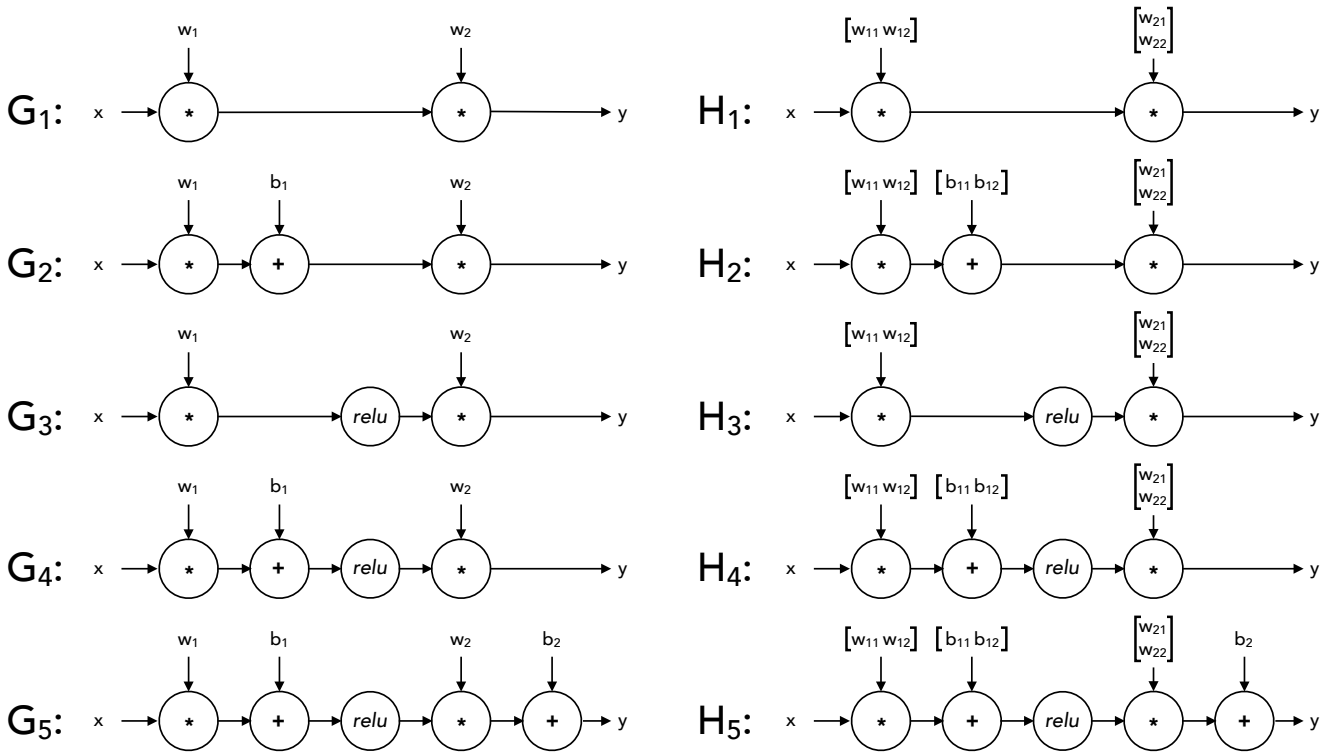
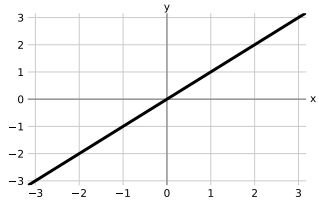
Q1. Neural Networks: Representation

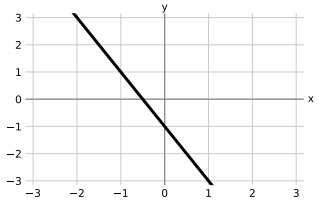


For each of the piecewise-linear functions below, mark all networks from the list above that can represent the function **exactly** on the range $x \in (-\infty, \infty)$. In the networks above, *relu* denotes the element-wise ReLU nonlinearity: $relu(z) = max(0, z)$. The networks G_i use 1-dimensional layers, while the networks H_i have some 2-dimensional intermediate layers.

(a)

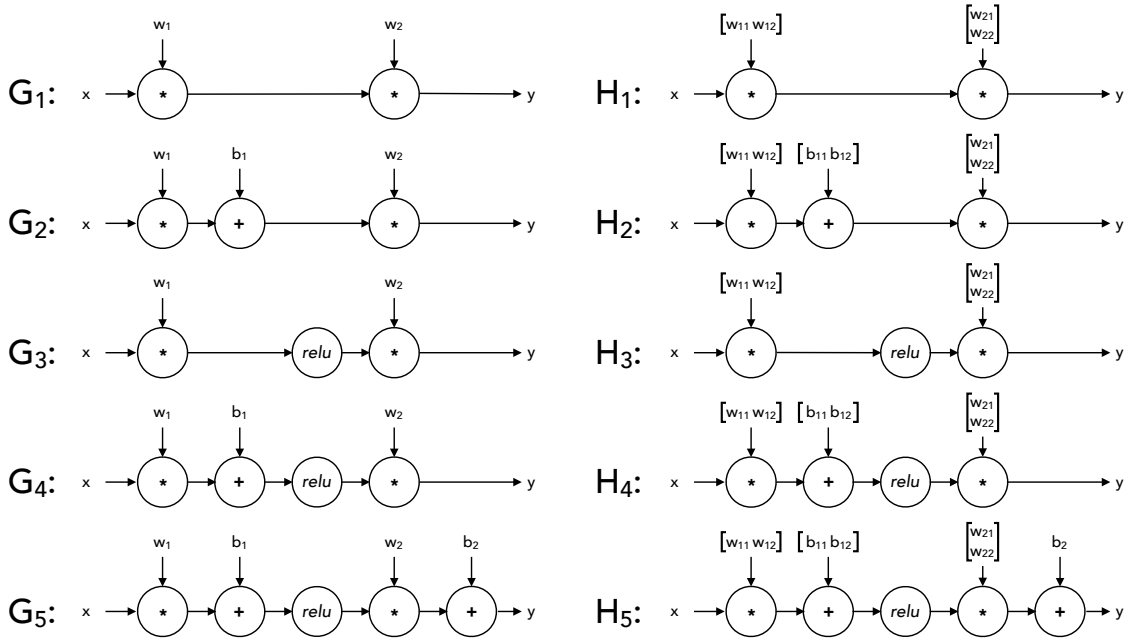


☐ G_1 ☐ H_1
☐ G_2 ☐ H_2
☐ G_3 ☐ H_3
☐ G_4 ☐ H_4
☐ G_5 ☐ H_5
◯ None of the above

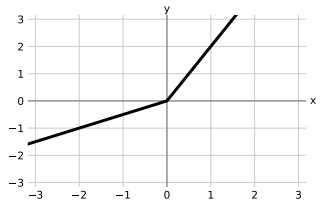


☐ G_1 ☐ H_1
☐ G_2 ☐ H_2
☐ G_3 ☐ H_3
☐ G_4 ☐ H_4
☐ G_5 ☐ H_5
◯ None of the above

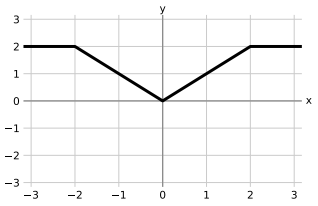
The list of networks is reproduced below for your convenience:



(b)

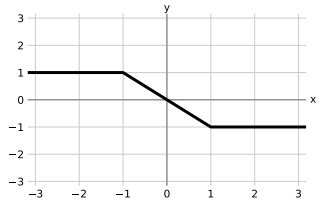


- ☐ G_1 ☐ H_1
- ☐ G_2 ☐ H_2
- ☐ G_3 ☐ H_3
- ☐ G_4 ☐ H_4
- ☐ G_5 ☐ H_5
- ◯ None of the above

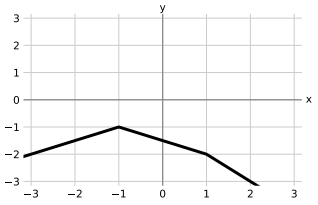


- ☐ G_1 ☐ H_1
- ☐ G_2 ☐ H_2
- ☐ G_3 ☐ H_3
- ☐ G_4 ☐ H_4
- ☐ G_5 ☐ H_5
- ◯ None of the above

(c)



- ☐ G_1 ☐ H_1
- ☐ G_2 ☐ H_2
- ☐ G_3 ☐ H_3
- ☐ G_4 ☐ H_4
- ☐ G_5 ☐ H_5
- ◯ None of the above



- ☐ G_1 ☐ H_1
- ☐ G_2 ☐ H_2
- ☐ G_3 ☐ H_3
- ☐ G_4 ☐ H_4
- ☐ G_5 ☐ H_5
- ◯ None of the above

Q2. Decision Trees

You are given points from 2 classes, shown as +'s and ·'s. For each of the following sets of points,

1. Draw the decision tree of depth at most 2 that can separate the given data completely, by filling in binary predicates (which only involve thresholding of a *single* variable) in the boxes for the decision trees below. If the data is already separated when you hit a box, simply write the class, and leave the sub-tree hanging from that box empty.

2. Draw the corresponding decision boundaries on the scatter plot, and write the class labels for each of the resulting bins somewhere inside the resulting bins.

If the data can not be separated completely by a depth 2 decision tree, simply cross out the tree template. We solve the first part as an example.