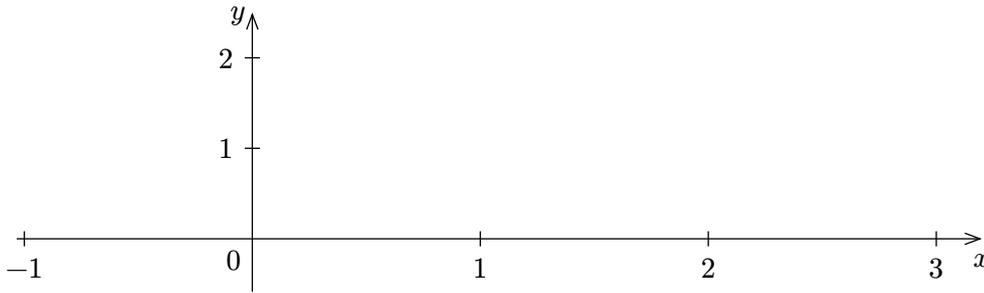


1. **ReLU as Hinge:** Sketch what $\text{relu}(x - 1) - 2 * \text{relu}(x - 2)$ looks like as a function of x , from $x = 0$ to $x = 3$.



2. **Tax brackets as an MLP.** Suppose tax is computed as: 0% on income up to \$10k, then 20% on income from \$10k–\$30k, then 30% above \$30k. Suppose someone earns \$50k: that’s \$10k in the 0% bracket, \$20k in the 20% bracket, and \$20k in the 30% bracket. they’d pay (in \$k) $0 * 10 + 0.2 * 20 + 0.3 * 20 = 10$.

a. Fill in the table to see how we can compute this using ReLUs:

x	$f_1 = \text{relu}(x)$	$f_2 = \text{relu}(x - 10)$	$f_3 = \text{relu}(x - 30)$	tax
0	_____	_____	_____	\$0
10	_____	_____	_____	\$0
30	_____	_____	_____	\$4k
50	_____	_____	_____	\$10k

b. Find weights w_1, w_2, w_3 such that: $\text{tax} = w_1 f_1 + w_2 f_2 + w_3 f_3$

$w_1 = \text{_____}, w_2 = \text{_____}, w_3 = \text{_____}$

c. This is a 2-layer network: input \rightarrow linear+ReLU \rightarrow linear \rightarrow output. What are the weights and biases of the *first* linear layer (the one before the ReLU)?

$w_1 = \text{_____} \quad b_1 = \text{_____}$

3. **MLP Shapes.** An MLP classifies 28×28 grayscale images (given as a flat 768-dimensional vector for each image) into 10 digit classes. It has one hidden layer with 128 units. Trace the shapes for a batch of 16 images:

- a. Input: X . shape = _____
- b. w_1 . shape = _____,
- c. After first linear layer: Z_1 . shape = _____
- d. After ReLU: A_1 . shape = _____
- e. w_2 . shape = _____,
- f. Logits: Z_2 . shape = _____
- g. After softmax: probs. shape = _____
- h. How many total learnable parameters does this network have? _____
- i. Label each part of this PyTorch code with the corresponding step (a–g) above:

```
linear1 = nn.Linear(784, 128) # ____
linear2 = nn.Linear(128, 10) # ____
Z1 = linear1(X) # ____
A1 = F.relu(Z1) # ____
Z2 = linear2(A1) # ____
probs = F.softmax(Z2, dim=1) # ____
```

How many “hidden units” does this network have?

Before you leave, pick a couple of these questions to react to:

- What was the most important concept from today for you?
- What was the muddiest concept today?
- How does what we did today connect with what you've learned before?
- What would you like to review or clarify next time we meet?
- What are you curious, hopeful, or excited about?