Last class (August 22)

1) Recap — Quizzes
2) Sensitivity and Specificity
3) ROC curve
4) AUC under ROC curve
5) Precision Recall Curve
6) Handling Imbalance Data
   - → class weights
   - → Oversampling of minority
   - → Undersampling of majority
   - → SMOTE

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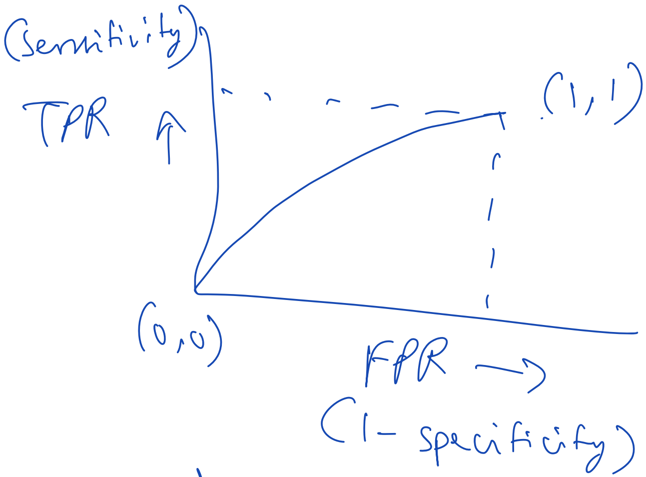
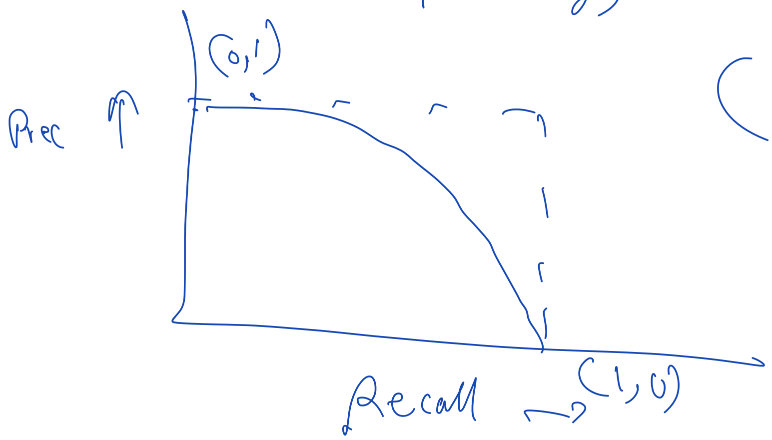
Today's class

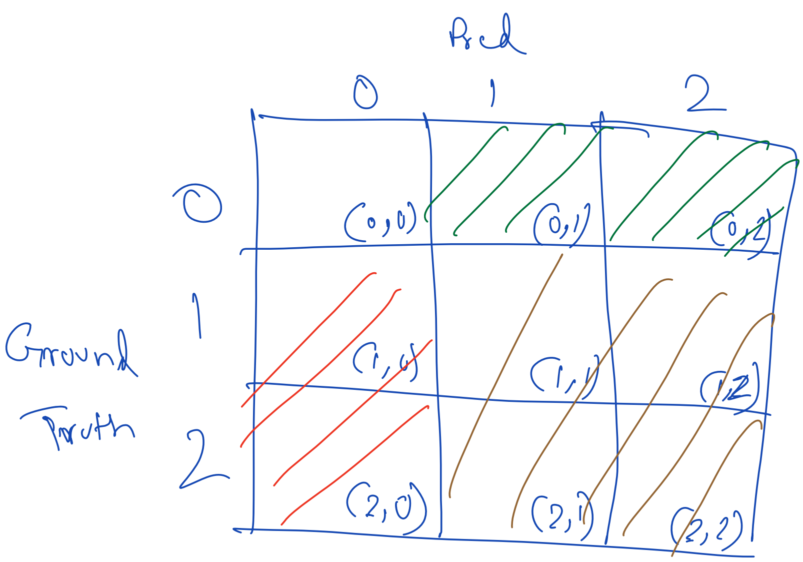
1) Recap — Quizzes ✓
2) Spiral data problem statement ✓
3) Linear ML vs Non-linear ML models ✓
4) Intro to NN
5) Real-world applications of NN
6) Biological Neuron vs ANN
7) Logistic Regression as ANN
8) History of ANN
9) Solving Spiral data problem with ANN



(TPR, FPR)
(0, 0)
(1, 1)
ROC curve



(Prec, Recall)
(0, 1)
(1, 0)



$TP_0 = (0,0)$

$FP_0 = (1,0) + (2,0)$

$FN_0 = (0,1) + (0,2)$

$TN_0 = (1,1) + (1,2) + (2,1) + (2,2)$

Random Model Acc $= \frac{1}{3}$

Logistic Reg Acc ≈ 0.52

Log Reg Acc > Random Acc

$$z = w^T x + b$$

$$\sigma(z) = \boxed{\frac{1}{1+e^{-z}}} = p \ (0 \text{ to } 1)$$

$$\text{i/p } (x) \longrightarrow \overset{w,\,b}{\bigcirc} \longrightarrow \sigma(z) \ (\text{o/p})$$

Log Reg

<u>Log Reg with Poly Features</u>

$$\text{i/p } (x) \longrightarrow \underset{\text{Transform Polynomial}}{\bigcirc} \longrightarrow \overset{w,\,b}{\bigcirc} \longrightarrow \text{o/p } \boxed{\sigma(z)}$$

$(x_1, \ x_2)$ $\quad$ $(x_1, x_2, x_1^2, x_2^2, \ldots)$

$$z \longrightarrow \boxed{e^z} \longrightarrow z, \ z^2, \ z^3, \ \ldots$$

$$z \downarrow \boxed{w^T x}$$

$$z \rightarrow \left[\begin{array}{l} e^{k_1 z} \rightarrow 1 + k_1 z + \frac{(k_1 z)^2}{2!} + \frac{(k_1 z)^3}{3!} + \dots \\ e^{k_2 z} \rightarrow 1 + k_2 z + \frac{(k_2 z)^2}{2!} + \frac{(k_2 z)^3}{3!} + \dots \\ \vdots \\ e^{k_n z} \end{array}\right.$$

$$2 + (k_1 + k_2) z + z^2 \left[\frac{k_1^2 + k_2^2}{2!}\right] + \dots$$

$z.$

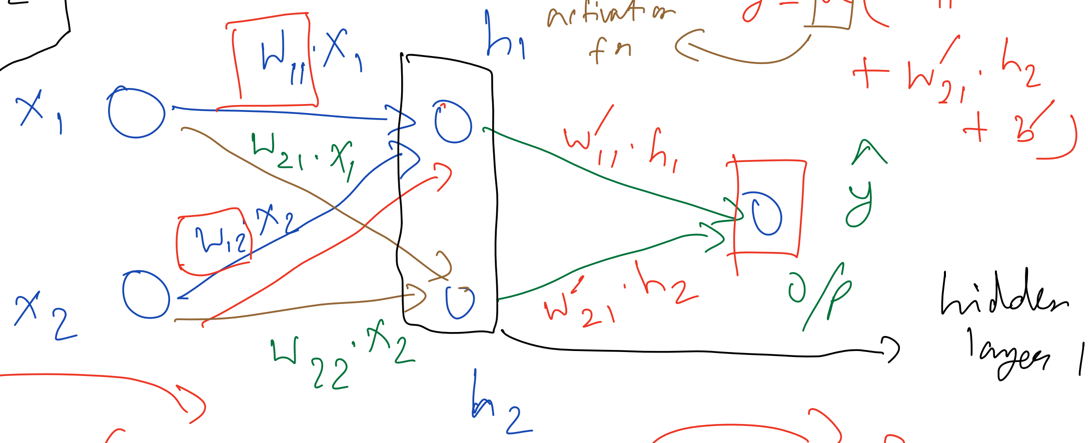
$$\boxed{\alpha_1} e^{k_1 z} + \boxed{\alpha_2} e^{k_2 z} + \boxed{\alpha_3} e^{k_3 z} + \dots \alpha_n e^{k_n z}$$

breadth = 2

depth = 1

non-linear activation fn

$$\hat{y} = \boxed{a}\left(w'_{11} \cdot h_1 + w'_{21} \cdot h_2 + b'\right)$$



$$h_1 = a\left(w_{11} x_1 + w_{12} x_2 + b_1\right) \rightarrow z_1$$

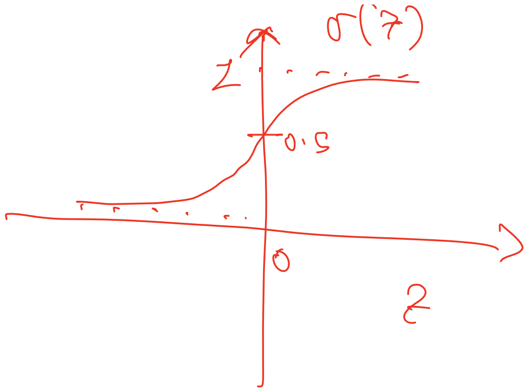
Activation Function $\rightarrow$ $\sigma(z_1)$

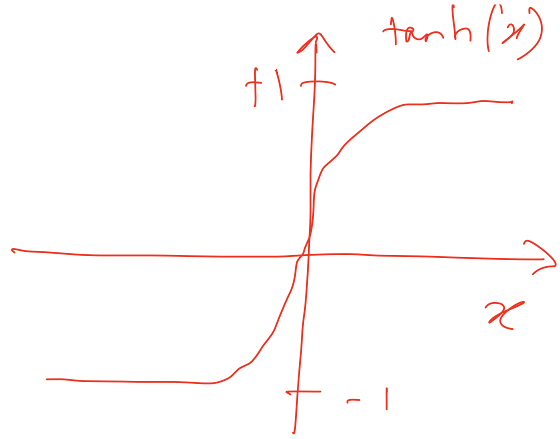
$\tanh(z_1)$

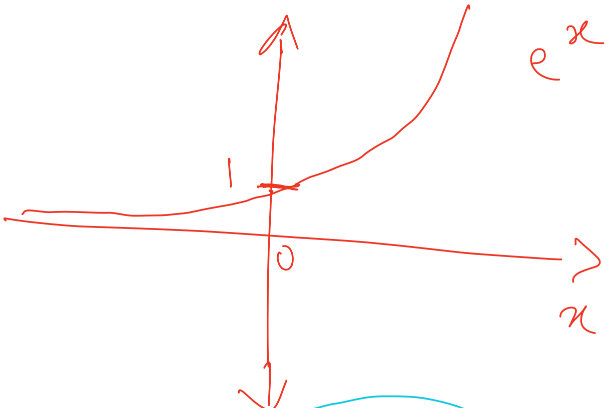
$\mathrm{Relu}(z_1)$

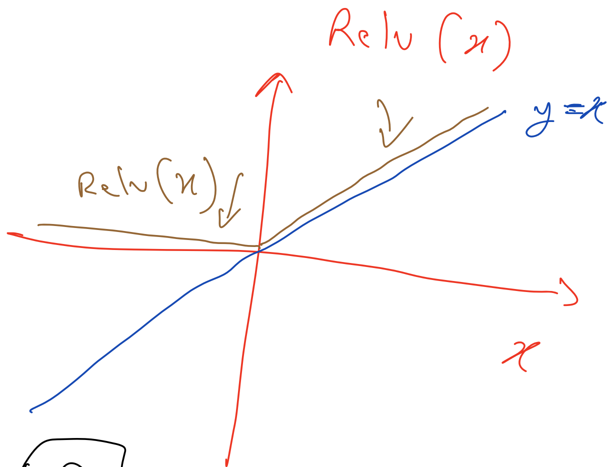
$\exp(z_1)$

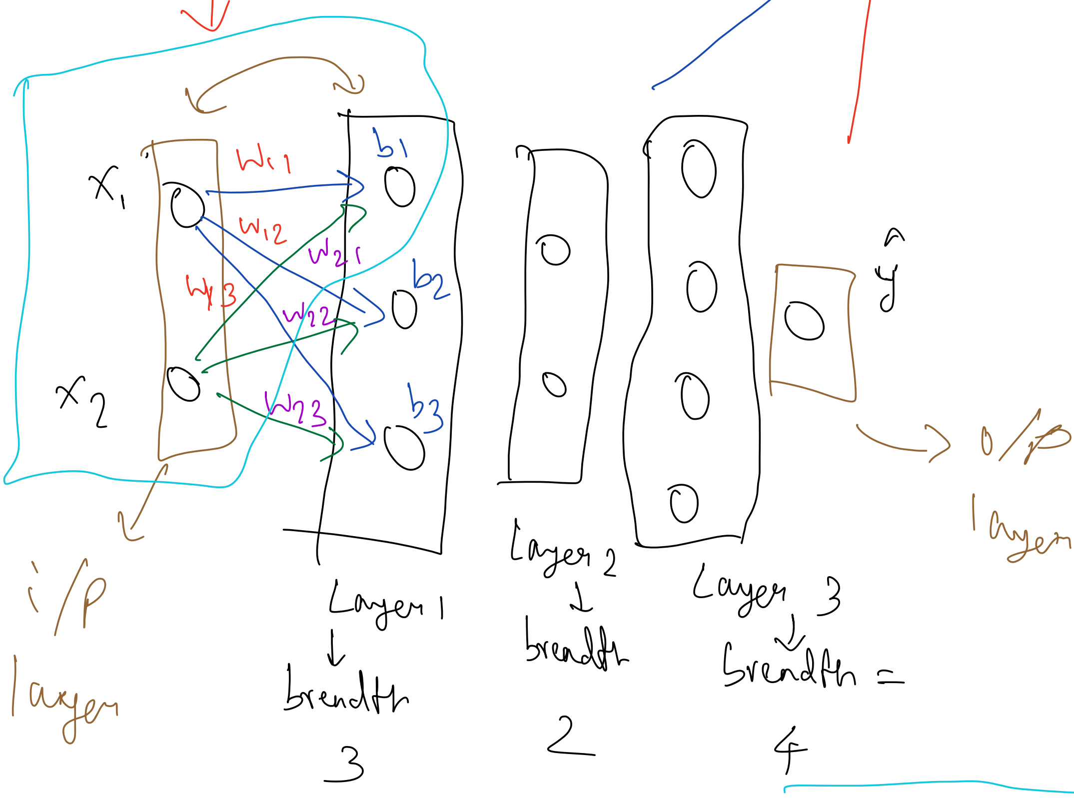
$$h_2 = a\left(w_{21} \cdot x_1 + w_{22} \cdot x_2 + b_2\right)$$

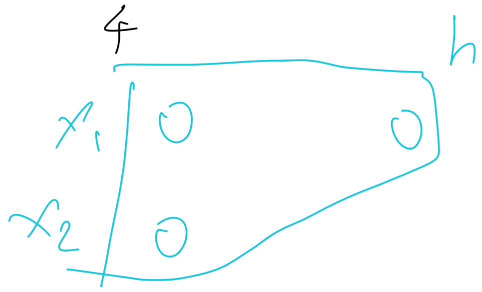

σ(z)
1
0.5
0
z


tanh(x)
+1
-1
x


e^x
1
0
x

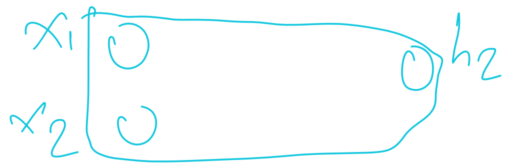

Relu (x)
y=x
Relu(x)
x

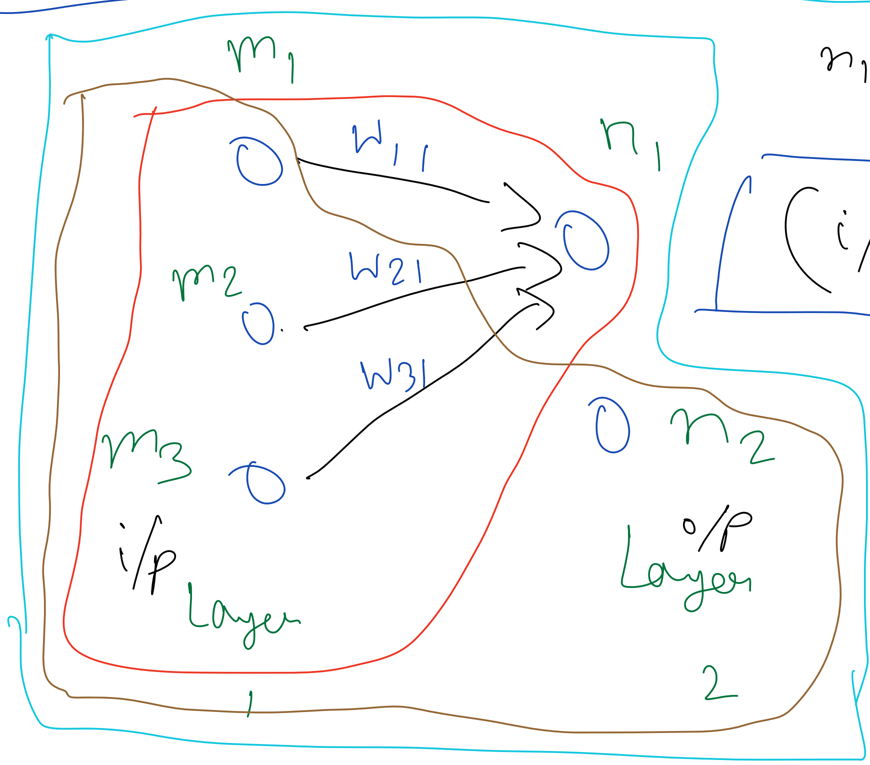

x1
x2
w11
w12
w13
w21
w22
w23
b1
b2
b3
ŷ
o/p layer
i/p layer
Layer 1
breadth
3
Layer 2
breadth
2
Layer 3
breadth =
4


h1
x1
x2

$(2+1) \times 3$

$|(i/p + 1) \times o/p|$





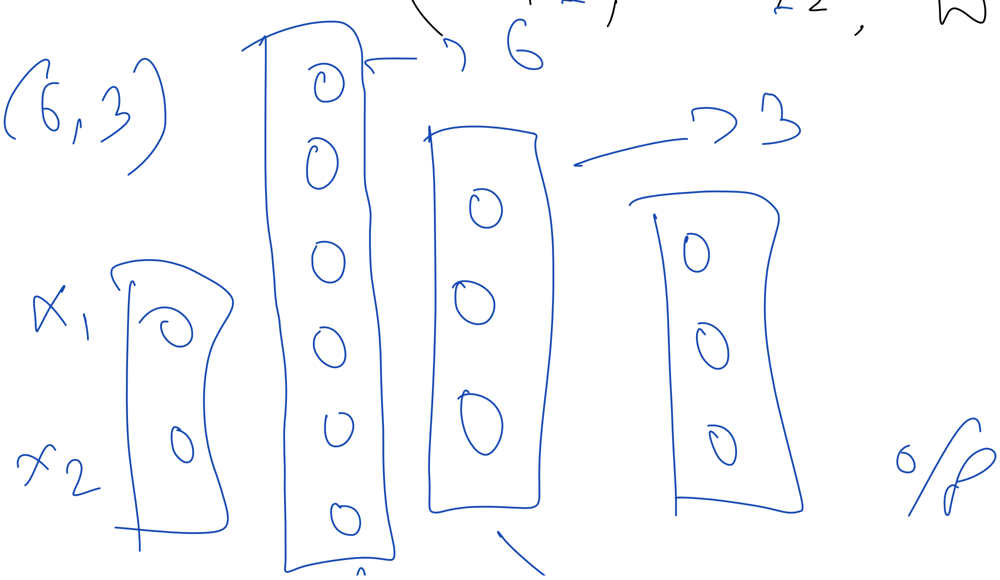
$n_1 \to m_1, m_2, m_3, b$

$(i/p + 1) \times o/p$

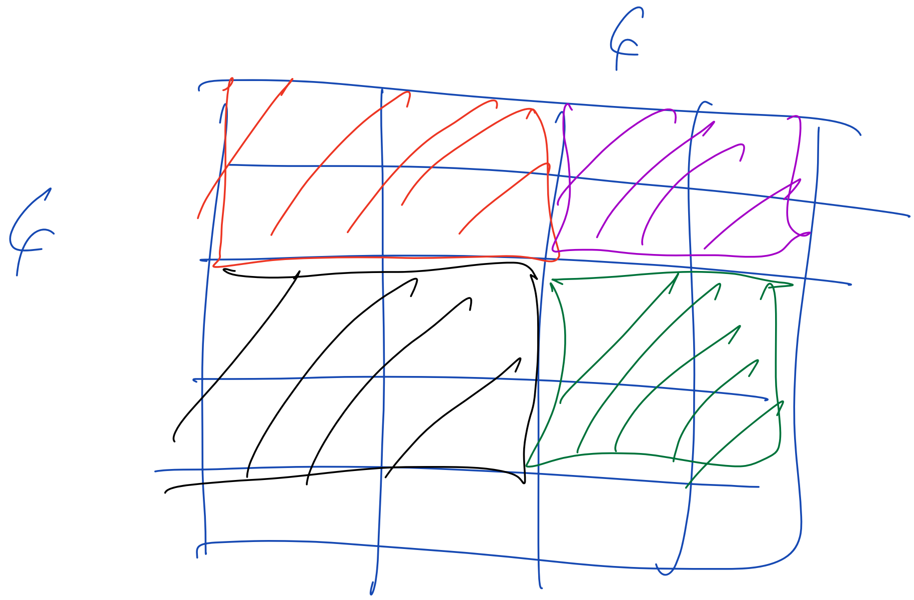
$n_1 \to (\underline{w_{11}}, \underline{w_{21}}, \underline{w_{31}}, \underline{b_1})$ 4

$n_2 \to (w_{12}, w_{22}, w_{32}, b_2)$ 4

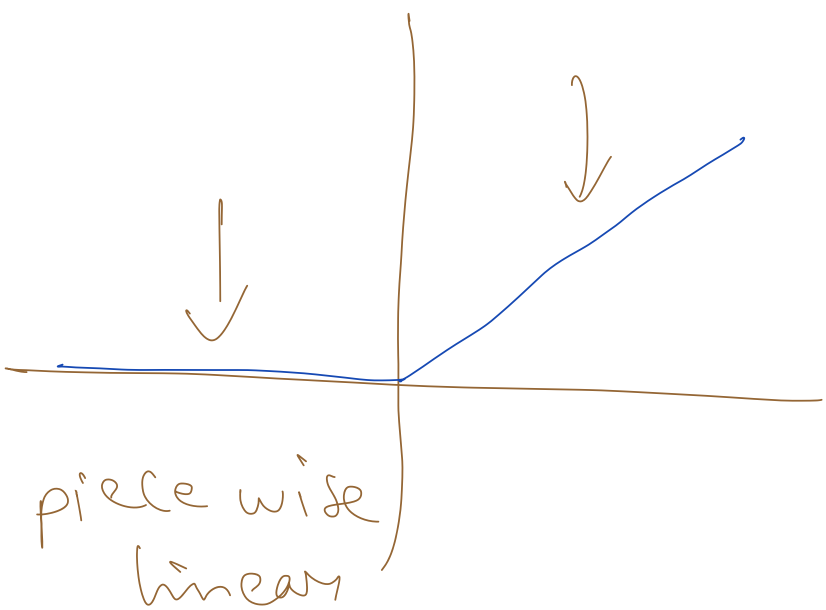
(6, 3)



i/p → Layer 1 → Layer 2



MLP → Multi-layer Perceptron

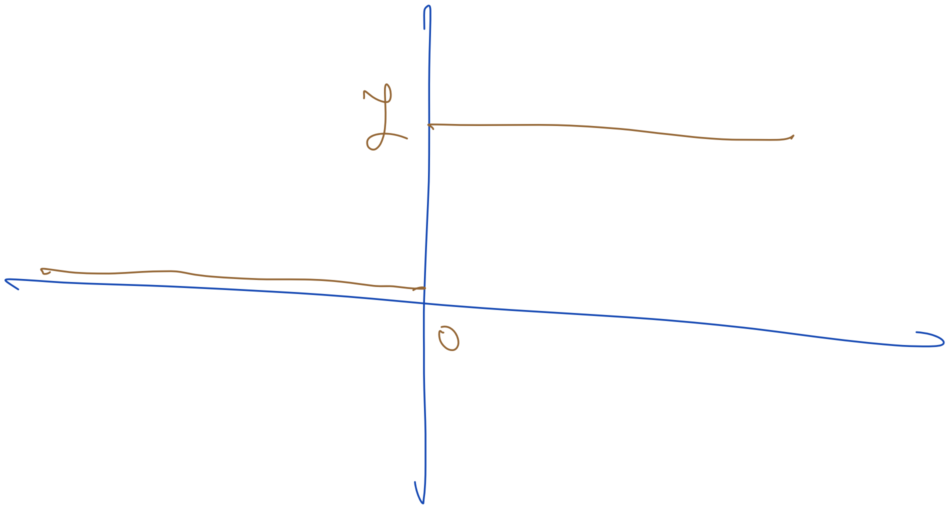


$y = x \quad | \quad x > 0$

$y = 0 \quad | \quad x < 0$

$\frac{dy}{dx} = 1 \quad | \quad x > 0$

$dy/dx = 0 \quad | \quad x < 0$



$$\begin{array}{ccccc} X & & W & & y \\ \begin{bmatrix} x_{1,1} & x_{1,2} & x_{1,3} \\ \vdots & & \\ x_{500,1} & x_{500,2} & x_{500,3}\end{bmatrix} & & \begin{bmatrix} w_1 \\ w_2 \\ w_3\end{bmatrix} & = & \begin{bmatrix} y_1\\ y_2 \\ \vdots \\ y_{500}\end{bmatrix} \\ (500\times 3) & & (3\times 1) & & (500\times 1)\end{array}$$